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ABSTRACT

The design of the monograph concentrates on scientists and technicians, reviewing and synthesizing available research findings related to vocational choice. Recommendations are limited to the study of personal and environmental factors influencing career paths toward the sciences and technology during the educational years. Two primary purposes of the study are: (1) to guide future research and (2) to identify environmental factors which can be manipulated by manpower agencies to influence both the scientific manpower supply and the composition of that supply. The first major section organizes literature related to stimulus or environmental variables. The stimulus variables reviewed are the macro-social systems of: (1) social class, (2) geographic influences, (3) religion, (4) community, and (5) racial and ethnic background, and the micro-social systems of: (1) the family, (2) peer groups, and (3) the school. A second section discusses response variables including academic ability, aptitudes, academic achievement, interests, personality, and vocational choice. The final section synthesizes the research results, using the educational structure as the basic organizing system, and is divided into three major sections: the early school years, high school years, and collegiate years. Two brief appendixes offer a synthesis model and a survey of work in progress. A 43-page bibliography completes the document. (MW)

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MONOGRAPH TWELVE:

SCIENTIFIC AND TECHNICAL CAREERS: FACTORS INFLUENCING DEVELOPMENT DURING THE EDUCATIONAL YEARS

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SCIENTIFIC AND TECHNICAL CAREERS

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A Final Report
to
The National Science Foundation

The American College Testing Program (ACT) is dedicated to the enrichment of education. It was founded as a public trust and operates as a nonprofit corporation governed by elected educational representatives from individual states or regions, and by a Board of Trustees.

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PREFACE

A society and economy like ours depends heavily on people in scientific and technical careers. Not only is industrial production planned and supervised by scientists and technicians, but new developments and innovations which relate to our future economic well-being depend on people in these occupations. It is clear that the public has an interest in their career development. From the broader perspective of vocational psychology we are interested in the career development of people in all occupations, and the study of scientists and technicians is helpful, particularly as the relationships discovered here may be applied to better understanding of career development generally.

The design of this monograph, of course, was to concentrate on scientists and technicians, and to synthesize available research findings relating to vocational choice. Research represented here was conducted by Philip R. Rever, Associate Director of Applied Studies in the ACT Research and Development Division, as a part of a contract with the National Science Foundation, award number NSF-C675. Reproduction of the work is with permission of the National Science Foundation.

With the renewed interest educators have in career development stimulated by national focus on career education, this monograph is timely. Research in career development is rich in suggestion for career education. The American College Testing Program is pleased to make the work generally available.

Leo A. Munday, *Vice President*
Research and Development Division

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Dr. John O. Crites, Professor of Psychology at the University of Maryland graciously advised and reviewed the work. His reactions and guidance were invaluable.

Ms. Mary Settle and Mr. Jerry Toomer were employed as research assistants to conduct the review of literature and survey of work in progress. Their thoroughness in the assigned tasks is amply represented by the extensiveness and scope of the topics in the bibliography.

Ms. Barbara Burke typed, edited and retyped the manuscript for what must have seemed to have been an innumerable number of times and the quality and speed of her work is gratefully recognized. Sandra Lutz had the major editing responsibility and her work is greatly appreciated.

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While it is a pleasure to acknowledge the contributions of those directly and indirectly involved in the project, the responsibility for the contents of the report is that of the author.

Philip R. Rever

Iowa City, Iowa
July, 1973

Chapter I

INTRODUCTION

The career development of scientists has played an unusually important role in the emergence of that branch of psychology known today as vocational psychology. The names of some of the most eminent psychologists have been associated with the study of scientific careers over the years beginning perhaps with Roe's (1946, 1949a, 1949b, 1950, 1951, 1952a, 1953) studies of physical scientists, psychologists, biologists, and anthropologists which led to her original theory of the early determinants of vocational choice (Roe, 1957). During the same early period in the history of vocational psychology, men such as A. W. Astin (1963), Cooley (1963a, 1963b), Holland (1957), O'Hara (1959), and Super (Super & Bachrach, 1957) and women like H. S. Astin (1969) and Tyler (1964) as well as Roe have directly studied the career development of scientists while engaged in their theory building and research.

Why the focus on scientists as subjects in the study of career development? In Roe's case it was due to her close contact with scientists through her husband, who was an eminent scientist in his own right. Later the interest in scientists as an occupational group was fostered with the onset of the space race in 1958 with the launching of Russia's Sputnik, which called national attention to the U.S.'s scientific resources. The nation's concern over science and technology was expressed through the work of the federal agency with primary responsibility for support of nondefense related scientific inquiry, the National Science Foundation, the agency which sponsored Super and Bachrach's (1957) earlier review of the literature on factors related to the career development of scientists. And it is the same agency for which this report was prepared.

Objectives of the Study

Like Super and Bachrach's (1957) earlier work, this report is a review and synthesis of research on correlates of scientific and technical career choices.

However, the review and synthesis of literature was only a means to an end which in this study was the preparation of a series of recommendations regarding the topics and directions for future research. Further, the recommendations were to be limited to the study of personal and environmental factors influencing career paths toward the sciences and technology during the educational years. The boundaries of the educational years were imposed on the study not only to keep it within a manageable framework, but more importantly to concentrate on personal and environmental factors which operate during an important period of time, the period in a young person's life before he or she enters into a scientific or technical occupation. The federal government is concerned about the oversupply of manpower in some scientific fields, particularly aeronautical engineering, defense and space engineering; the undersupply in other fields, particularly civil engineering and social sciences; and the lack of adequate representation of members of racial and ethnic minorities and women in science and technology (Manpower Report of the President, 1972). Consequently, the review is not only to lead to recommendations for future research, but to guide the federal government in making policy decisions on how to influence future scientific manpower supplies while the future work force is in school. Thus, it is fitting to limit the study to personal and environmental factors influencing career development during the educational years.

In summary, there are two primary purposes of this study: first, to guide future research on career development during the educational years and secondly, to identify those environmental factors which can be manipulated by manpower agencies to influence both the scientific manpower supply and the composition of that supply. Three steps were necessary to accomplish these objectives. The first was a review of literature to determine what is known and what is not known about personal and environmental influences on career development during the educational years. The second step was to conduct a survey of work in progress so that the recommendations for future research could be made in light of current research activities. The third step was to synthesize the results of the first two steps.

The Literature Search

The first step in the process of preparing this report was the initiation of a literature search. The starting point was the comprehensive works of Crites (1969), Osipow (1968), and Roth, Hershenson, and Hilliard (1970) in vocational development which served as initial sources to studies directly related to choice of, change from, and persistence toward scientific or technical careers. Since these authors review and evaluate the general research in vocational development we were able to identify studies in our area of concern and benefit from their evaluations of each work.

In addition to examining the references in the three texts, the usual indexes of social science literature were employed, as well as bibliographies and reference lists contained in reports of research.

Work in Progress

In addition to the search of past studies, a survey of work in progress was made. Two approaches were employed in this survey. First, we corresponded with known scholars in the area of vocational development and behavior. Also included in the correspondence were less well-known individuals identified as a by-product of the literature search. The second approach used grants and contracts awarded through the four major federal agencies concerned with manpower studies. These agencies are the United States Office of Education, the National Science Foundation, the National Institutes of Health, and the United States Department of Labor (Annual Register of Grant Support, 1969, 1970). Every effort was made to contact and communicate with persons currently working on projects related to the objectives of this report.

Evaluation of Research

As each study identified through the literature search and survey of work in progress was reviewed, four criteria were used in making the decision to include it in the report. The criteria were:

1. Relationship to our area of concern.

2. Clarity and significance of the research effort.

3. Methodology — design and analysis of evidence including sampling, sample size, and statistical analysis.

4. Appropriateness of conclusions.

Obviously, the primary criterion used in deciding which studies to include and which studies to exclude was the first stated, relevancy. The relevancy of a research program to a review is a function of the criterion or dependent variable. Consequently, some thought had to be given to answering the question "what dependent variables are appropriate in determining whether a student is moving toward or away from a scientific or technical career?"

Vocational psychologists use four approaches in dependent variable assessment, i.e., the determination of whether or not a subject is on a particular education or career path. One approach is the longitudinal or postdictive study which waits until the subject enters the occupational world and then classifies him or her as being on a particular path, say science or nonscience. A second method commonly used with subjects during their later educational years is to ask them to state the career they are most likely to enter after completing their formal education. The third approach is somewhat more sophisticated than the latter and it requires that the paths leading to a particular career be clearly defined according to the activities which constitute the path. Then by determining whether or not the subjects are engaged in those activities, he or she can be identified as being on the path or not. The fourth and final method is a pooled approach which uses various combinations of the other three.

The focus of this review, because of its purposes, is on those factors influencing development between decision points. We refer to these factors as antecedent variables.

Why are antecedent variables included and what are these antecedent variables? Antecedent variables are those which can be rationally related to the choice of one educational path over others at different times during the educational years. For example, one antecedent variable is interest in science as an elementary school student. Another example is level of aspiration. One more example is the choice of an academic or college preparatory series of high school courses. It is reasonable to assume that an elementary student who is disinterested in science in elementary school is not likely to enter a scientific career. It is also reasonable to assume that a student with a low level of educational and vocational aspiration will not follow an educational path that leads to college or advanced training in the sciences. Similarly, the high school student who is taking a commercial high school curriculum is not likely to decide to pursue a course of study in college leading to an engineering degree. The inclusion of studies which use antecedent variables as dependent variables is required because of the nature of educational paths.

During the early school years, paths are undifferentiated. It is not until high school that some differentiation occurs and thereafter multiplies rapidly. Consequently, it is not sufficient for the purposes of this study or for understanding the factors related to persisting on an educational path to the sciences, to concentrate simply on the period of time during the educational years when subjects' statements of career goals stabilize. It is much more informative to concentrate on the decision points in the educational paths and to determine those factors which are related to choosing one path over another, particularly during the early school years and the high school years.

The consequence of the decision to include studies which concentrate on antecedent variables is broadening of the review of literature as well as extending the literature downward to include the early and middle school years.

Once the relevancy of a study was determined it was reviewed within the framework discussed next.

Organization of Review

A number of comprehensive schemes are available as methods of synthesizing research findings. Many of those writing about vocational development and behavior—Osipow (1968) and Roth, Hershenson, and Hilliard (1970), for example—have organized their work around various psychological theories in vocational psychology. Such a theoretical approach, although helpful to the student of vocational psychology, acts as a barrier to synthesis of the research results and was therefore inappropriate for this study.

Rather, we chose to use a scheme adapted from that used by Crites (1969) for his review of the field. In presenting his analysis of research results, he adopted the stimulus—organism-response model of behavior as a way of organizing the findings. An outline of Crites' model can be found in Appendix A. Such a model clearly delineates the environmental, personal, and intervening correlates of vocational choice and development. Moreover, his comprehensive scheme includes the work of sociologists, educators, anthropologists, and representatives of other disciplines. Of the models for synthesis which could be used, Crites' appeared to be the most comprehensive.

While Crites' model was adopted as the organizing framework of this report, it has been adapted to meet our particular needs. For example, father's occupation is discussed as both a socioeconomic factor and a family influence where Crites considered it only as a family influence. Further, only his first and third major divisions—stimulus and response—are included, not by choice, but because we were unable to identify any studies of the relationship between science career choice and "organism" variables.

Many of the studies reviewed include results appropriate to several categories in our categorization scheme. While it may seem repetitious to include an overview each time a study is mentioned, an effort has been made to make each section as complete as possible for the benefit of the many readers who are concerned only with particular subareas of our study.

Synthesizing the Results

The fourth chapter of the report synthesizes the findings in a general developmental framework. Although a particular theory of career choice might have served as a valuable frame of reference, the general approach was selected to avoid the danger of ignoring research not applicable to a single theory. More importantly, it was selected to facilitate the process of guiding decisions on how to influence the future composition and supply of scientific and technical manpower. Thus, it was decided to use a time frame which reflected the nature of career development during the school years and the sequential nature of preparation for entry into a scientific or technical career, both of which were discussed earlier in this chapter.

Chapter II

STIMULUS VARIABLES

Our first major section organizes literature related to what Crites (1969) calls stimulus or environmental variables. We have accepted his definition of this construct. Stimulus variables are essentially those physical events which can elicit a response and whose properties can be measured independently of the response. Thus, in this chapter we are concerned with those physical events in the environment of the individual that positively or negatively influence the response of development toward a career in science or technology. The stimulus variables reviewed here are the Macro Social Systems of: (a) Social Class, (b) Geographic Influences, (c) Religion, (d) Community, and (e) Racial and Ethnic Background; and the immediate environment or Micro Social Systems of: (a) the Family, (b) Peer Groups, and (c) the School.

The Macro Social Systems

The division of stimulus variables into the macro social systems and the immediate environment follows the lead of others (Rosen, Crockett, & Nunn, 1969) in discussing environmental influences on behavior. Because the macro social systems are larger conceptions of environmental influences and are composed of micro social systems, it seems natural to begin with them.

Social Class

While it is obvious that cognitive and personal development, as well as behavior patterns, are determined to some degree by social class, the concept itself is not simply defined. Roach, Gross, and Gursslin (1969) have compiled a number of papers which discuss uses of the concept and methods of determining social class. As J. A. Coleman (1969) makes explicit, the terms social class and social stratum are used to refer to a variety of phenomena including prestige, cultural, influential, psychological or associational phenomena. However, the most popular operational definitions of social class use what Coleman identified as the demographic perspective which only superficially accounts for the prestige, cultural, associational, influential, and social psychological perspectives.

In their earlier review of the vocational development of scientists, Super and Bachrach (1957) cited 16 studies that dealt with the relationship between scientist's offspring and level of socioeconomic status of parents as a general indicator of social class. They concentrated on research which used actual occupational category as the definition of vocational choice. The relationship between socioeconomic status and vocational choice had not been fully explored by 1957, but they did conclude that the natural scientist was generally favored with an upward-mobile, middle class background, although other backgrounds were represented among natural scientists. At the time of their review there was little evidence about the backgrounds of mathematicians and engineers, although they indicated that mathematicians apparently came from superior socioeconomic backgrounds.

Socioeconomic status (SES) is determined, of course, in a variety of ways. Typical indexes rely on such factors as parental income, parental educational achievement, and occupation. These are included as subsections.

Occupations of Parents. There have been several approaches used in studying the relationship of parents' occupation to offspring's vocational choice, preference, or aspiration. One approach is to use level or prestige of father's occupation as an index of SES. Another approach, similar to social mobility research, focuses on the inheritability of an occupation.

Bull (1954) was one of the earliest to use the pool approach to identify vocational choice. His purpose was to explore the relationship between an expressed interest in science classes or science-related hobbies and background factors which he termed conditioning experiences. Using interview data collected from 100 high school pupils enrolled in science classes in 22 Missouri schools, he concluded that the typical high school student with science interests or activities had a father whose occupation was directly related to science and could be classified as professional, semi-professional, or self-employed.

In his doctoral dissertation, MacCurdy (1954) attempted to isolate factors in the backgrounds of superior science students which might differentiate them from the general population. He surveyed the 80 winners and 520 honorable mention recipients in the 1952 and 1953 Science Talent Search, all freshmen and sophomores in high school. He reported that among the relatives of his subjects were many teachers and scientists; this was not true of a control group of 78 high ability students who were not winners. In a later study (MacCurdy, 1956), the same subjects were assigned by judges to five groups: (a) scientific scholars, (b) potential scientists, (c) potential engineers, (d) women in science, and (e) potential professional people. There were no major discernible differences in father's occupations among the five groups.

Dole and Sherman (1964) analyzed differences in backgrounds of a sample of 3,768 9th-grade males in public schools in Hawaii. From questionnaire data, they found that of the 1,009 freshmen electing science courses, 35% had fathers who were skilled workers and 15% had fathers classified as being employed in domestic, personal, or protective work, with the remainder working in higher level occupations.

Two studies were conducted using participation in the Georgia State Science Fair Awards as an indication of a scientific vocational choice. Koelsche (1965) collected and analyzed data from interviews with winners and questionnaires from their school personnel in an attempt to characterize the 54 winners from 1959, 1960, and 1961. He found that they typically came from families where the father's occupation was classified as professional, proprietary, and managerial. However, with no comparison data, it is not possible to assess the significance of this finding in relation to vocational development. Norman (1965) pursued a more sophisticated course by following 430 science fair participants from the period 1955-1962 after they left high school. In an effort to identify differentiating characteristics, he divided his 281 respondents into two categories: (a) those who pursued a science-related career, and (b) those who did not. Fifty-three percent of the respondents had entered or were in a science-related college program. Although he reported no significant differences between the two groups in father's occupational category, the highly homogeneous nature of the original population may account for such a finding.

In a study designed to help teachers identify and encourage scientific talent, Daniels (1966) surveyed 226 freshmen at Winchester High School in Massachusetts. Of the 122 subjects electing to take General Science, 7.5% reported that their fathers were engaged in science-related occupations, while 60% were executives and 27% were laborers.

Moving a step closer to vocational choice as defined by vocational psychologists, we found several studies of the relationship between the level of father's occupation and offspring's actual choice of a science career. In the culmination of a series of studies of specialized talent sponsored by the Commission on Human Resources and Advanced Training, Wolfe (1954) assessed the relationship between father's occupation and offspring's vocation. Wolfe's sample consisted of 20% of all June 1951 college graduates plus a special sub-sample consisting of all 1930, 1940, and 1951 graduates of the University of Michigan and Ohio State University. In his analysis, Wolfe weighted the responses to represent the population of college graduates under the age of 70. He used father's occupation as an index of SES and examined the relation of the father's field to the graduate's field of work. Socioeconomic factors were related to college attendance patterns, but only small differences were found in distributions of father's occupations among those employed in specialized fields. Students who had majored in the arts and humanities were more likely than other students to have professionals or managers as fathers and less likely to have a skilled-trades father. Engineers and students in applied biology were decidedly more likely to have a father in the skilled trades. However, the degree of overlapping of father's occupations among all fields was extensive.

In his Scientific Careers Study, Cooley (1963a) used Roe's (1956) classification by level to classify father's occupation level as described by the father and by the son as one part of the SES of a student. Using a 5-year overlapping longitudinal design, Cooley studied the vocational development of students at two decision periods—first, the high school to college transition and second, the college to postcollege transition. The design of the study allowed Cooley to follow students for 5 years and gather data about the transition periods. He used a sample of 700 students from 10 communities within a 25-mile radius of Cambridge, Massachusetts. Following his earlier (Cooley, 1958) review of research, he used interview data to classify each of the 192 11th-grade students into one of four categories depending upon the type of college the student was planning to attend and his anticipated major field of study. The four groups were: (a) Potential Scientist Pool (PSP), (b) College Non-Science (CNS), (c) Non-College Technical (NCT), and (d) Non-College Non-Technical (NCNT). Using multiple discriminant analysis to examine the relationship between father's educational level and student plans, he concluded that when groups were compared on father's occupation there were no major discernible differences. Further, when comparing only the PSP and CNS groups, father's occupation did not differentiate between them. He states (p. 41) ". . . it does not make sense to talk about SES variables as being related to becoming a scientist, except in so far as one needs to go to college to become a scientist."

Five years later Cooley again contacted his 11th-grade subjects and classified them according to their college major at graduation and their future plans—Graduate School in science (GS), Medical and Dental School (MD), Applied Sciences (AS), Non-Science (NS). The original 192 subjects in his 11th-grade group had reduced to 100 by the time he gathered the 5-year data. Comparing the level of father's occupation among the four groups, he again found no significant difference. However he did report differences when classifying the father's occupation according to its closeness to science. Students whose fathers were in scientific or technological occupations were considerably more likely to be classified as GS or AS than as MD or NS. In one of the two discriminant functions based on "environmental" factors, science or nonscience classification of father's occupation carried the largest weight in classifying students.

Now we turn to those studies of the relationship between SFS as measured by level of father's occupation and vocational choice as defined by the subject's actual occupation. Visher (1948) reported that of 2,607 men whose names were starred in *American Men of Science*, 46% reported that their fathers were professionals, 22% businessmen, 22% farmers, and 8% skilled. Roe (1952b) studied 64 eminent scientists and found that 53% had fathers who were professionals. Terman (1954b) reported a 30-year study of 800 gifted men employed in: (a) Physical Science Research (PSR), (b) Engineering (E), (c) Medical-Biological Work (M-B), (d) Physical or Biological (nonresearch) Science (PBS), (e) Social Science (SS), (f) Law (L), (g) Humanities (H), or (h) Noncollege (NC). In this highly unusual group he found the following percentages of fathers in the professional class: PSR=53%, L=45%, E=30%, PBS=29%, SS=28%, and NC=18%.

As part of a larger study, L. R. Harmon (1965) analyzed the social mobility of PhDs in the sciences. Unlike most of the studies reported earlier, he reviewed the current occupational level of fathers of PhDs in terms of the age grouping of the PhD—to account for the changing occupational structure in the U.S.—and in terms of the occupational structure according to census data. He developed a systematic sample of each 5th-year cohort of science PhDs beginning in 1935. The sample was then reduced by randomization from year of graduation and field of specialization until there were 15,348 subjects, of which 14,831 were living at the time of the survey. The final data included responses from 10,020 subjects. He found a clear but diminishing relationship between being a scientist and level of father's occupation at the time of the survey—28.0% college teacher and other professional, 18.1% manager, 15.6% farm or farm management, 11.2% sales and service, 4.4% clerical, and 21.4% labor, including skilled, semi-skilled and unskilled. When the occupational level was related to the structure of occupations from census data by age of the subject, the relationship appeared to diminish further. This extensive study is particularly significant because it is the only one examining the strength of social class barriers to vocational development toward science. To study the relationship between father's occupational level and field of specialization, Harmon categorized the latter into nine areas. (a) basic medical, (b) other bio-sciences, (c) medical sciences, (d) agricultural, (e) psychological, (f) social, (g) mathematics, (h) physical, and (i) engineering. The professional classification was the modal level of occupation in each cohort for each field except for agricultural sciences, basic medical sciences, and engineering. Without more statistical analysis it is difficult to judge the importance of the differences among and within the fields.

H. S. Astin (1969) reported the results of a survey of 1,979 women who received doctoral degrees in 1957 and 1958. The survey was conducted over a 1-year period beginning in December 1965. Using data from a variety of sources including high schools, Office of Scientific Personnel of the National Academy of Sciences, as well as from 1,653 respondents, she gathered a sizable amount of background and career information about women PhDs. The subjects were asked to classify their parents' occupation at the time they were growing up—39.6% of the fathers were in business or managerial positions, 28.8% were professional, 18.2% were skilled, 8.3% were semi-skilled, and 5.0% were unskilled. Twenty-three percent of her subjects reported that while they were growing up, their mothers worked at the following levels: business or managerial (30.7%), professional (39.9%), skilled (11.5%) semi-skilled (10.6%), and unskilled (7.2%).

A number of studies used gross classifications of fathers' occupational levels to describe the background of scientists or potential scientists, that is they concentrated on a two- or three-class scheme of professional, white-collar, and nonwhite-collar classifications of occupations. Lehmann and Nelson (1960) found honor students in a natural science course were more likely to come from professional or white-collar backgrounds than were nonhonor students. West (1961) used the Kinsey, Pomeroy and Martin (1948) scale of levels of occupations and found that offspring of fathers at the upper end of the scale were more likely to go on to PhD work and those terminating their education at the MA level had fathers whose occupations ranked lower on the scale.

Schwartz (1965) reported data about a sample of scientists and technicians selected from the 1960 Census of the population. Her study, based on recommendations of the Advisory Panel to the National Science Foundation and the President's Committee on Scientists and Engineers, was designed to determine the relationships between training program and subsequent occupation. The sample consisted of over 70,000 persons employed in 40 scientific, technical and professional occupations classified as "professional, technical and kindred" by the Bureau of the Census. Data were obtained from 51,505 respondents in scientific and technical occupations and 4,663 from the remaining college graduates in the United States as of 1960. The respondents were asked to recall and record their father's occupation when the respondent was 16. The occupations were then placed in one of eight categories—professional-technical, farm owner or manager, manager and proprietor, craftsman or foreman, operatives and kindred workers, sales, labor and others. She then computed an index of advantage, similar to L.R. Harmon's (1965) which was based on the percentage of males in the occupational level in the population at the relevant time period. Similar to Harmon (1965) there was a positive relationship between age of college graduates and level of occupation of father. Unlike Harmon, however, the index of advantage indicated that having a father in the highest level was a distinct advantage to receiving the doctorate regardless of the age of the subject. The differences between the two studies may be due to Schwartz's specificity of father's occupation in relation to the subject's age or the method of classifying the occupations. When she examined the occupation of fathers by field of study in which the respondent held his highest degree, Schwartz found some differences. Almost equal proportions of fathers of engineers (21%), physicists (21%), chemists (20%), other physical scientists

(24%), and psychologists (25%) were classified as professional. The technical specialists had the lowest proportion of fathers classified as professionals (12%) while mathematicians were not far behind (14%). Managers and proprietors were the modal occupations of fathers for mathematicians and statisticians (25%), for physicists (38%), for chemists (26%), and for psychologists (31%). Craftsmen and foremen were modal occupations of fathers for engineers (23%) and for technical specialities (35%), while operatives and kindred workers were modal for fathers of physical scientists (26%) and professional-technical for biological scientists (33%). Thus, there were some variations in the backgrounds of subjects according to the field of study in which they had taken their highest degree.

Family Income. Because family income apparently is not a stable and reliable index of socioeconomic status, it is the least popular factor in determining SES. A further element inhibiting the use of family-income level as an index of SES is the reluctance of students to report family income because of its confidentiality or because they may not know the precise level of family income. In fact, level of family income was used as an SES index in only one study of the vocational development of scientists. A. W. Astin and Panos (1969) used the student's estimate of his family's income as a variable in the prediction of graduating major and probable career choice, all of which were obtained from the students after they graduated from college. They concluded:

> Students from wealthier families were more likely to stay in or to be recruited into careers as businessmen or lawyers than were students from less affluent family backgrounds, who were more likely to stay in or to be recruited into careers as engineers and school teachers. Parental income also carried a small positive weight in predicting a final major in physical science or mathematics. (p. 106)

Thus, while family income is seldom used as an index of SES, it seemingly does follow the same patterns as father's occupational level.

Education of Parents. Another popular index of SES is the educational level of parents. This tends, however, to be more often used in conjunction with other factors.

In his previously cited study of gifted men, Terman (1954) reported that 52% of his physical science researchers had fathers with baccalaureate degrees, as did 51% of his medical-biological group, 48% of his law group, and 26% of his engineering group. In 1964 Parkoff found that there were no differences in the educational backgrounds of the parents of 124 male former graduate students in science and engineering at Columbia University who had been working for 10-15 years. Norman (1965), using a similarly restricted sample of 430 participants in the Atlanta Science Congress, found no differences in the educational backgrounds of parents of those who continued on into a science-related career and those who did not.

In L.R. Harmon's (1965) study of 10,017 PhDs in the sciences, he reported data on the educational level of both parents by field of specialization. Although his cell sizes make it difficult to clearly understand the implications of the data, he did conclude that the educational levels of parents of PhDs are substantially higher than those of the population in general. The differences between fields are somewhat obscured by his data presentation, but it appears that medical scientists, agricultural scientists, and engineers have parents with lower educational levels than do other scientists, although there appear to be bimodal distributions for those in the medical sciences. The lower levels of educational backgrounds for medical, agricultural, and engineering scientists corresponds to Harmon's comparisons of occupational levels of fathers, although father's education seems to provide slightly more differentiation. Identical patterns were observed for mother's educational levels according to field of concentration.

In 1966 Werts reported the first of a series of studies (Werts, 1966 a & b, 1968) which related social class to the initial career choice of freshmen. The purpose of the studies was to separate class effects from father's occupation effects on the career choice of college freshmen. Part of his data came from A.W. Astin's (1965b) 1961 survey of 127,212 freshmen at 248 accredited 4-year colleges and universities, and the remainder came from a 12-page questionnaire sent to a random sample of 60,000 students in the summer of 1962. Father's occupation was hand coded into four groups according to the modal educational level of the fathers in the specific occupations in the group, thus resulting in a four-level index of SES based on father's education. The lowest group of occupations included fathers who had a high school diploma or less as the modal level of education, the second group had some college, the third had a baccalaureate degree, and the fourth had an advanced degree. Werts then distributed the father's occupation by field (18 fields) within SES level to establish expected career choices by field (15 fields) for the students based on the assumption (p. 76): "If father's occupation did not influence career choice, the percent of sons or daughters in each cell would be the same as the percent of fathers having the particular occupation." By testing for differences between expected and observed cell percentage, he could classify choices as over-chosen or under-chosen by students in each of the four SES categories. For the lowest SES category he found the men students over-chose engineer, teacher, chemist, accountant, clergyman, and farmer while women over-chose teacher, nurse, or lab technician, with each of these fields being under-chosen by the highest SES group. The careers over-chosen by men in the highest SES group were physician, lawyer, and college professor, and by women social worker, physician, foreign service, psychologist, and housewife; all of these except housewife were under-chosen by the lowest SES group, but not under-chosen by the two middle SES groups. The men from the two middle SES groups over-chose dentist, physicist, mathematician, architect, businessman, and foreign service; while women from the same groups over-chose journalist and speech therapist. Werts also reported that "where son's career choice matched father's occupation a significant degree of over-choice was observed." For example, sons of engineers were the only ones in SES Groups 2, 3, and 4 that over-chose engineering. Consequently, he warns that ignoring father's occupational field in studying SES effect on career development will be misleading.

Using the same data set from which Werts chose his sample, A. W. Astin and Panos (1969) used father's and mother's educational achievement level as SES indexes and as predictor variables in their study of the predictability of major field and probable career choice 5 years after entering college. When entering a stepwise multiple-regression system, they found that parent's level of education had almost no relationship to career choice, major, or change in major. Father's education had a small positive weight in predicting final major in liberal arts and humanities and mother's educational level had a small positive weight in predicting final career choice of physical science. Previously expressed career choice was the predictor with the greatest weight in all equations, suggesting that educational level or SES effect was generally accounted for in these earlier choices.

Although H. S. Astin's (1969) study of women doctorates graduating in 1957 and 1958 reported educational levels of both fathers and mothers, she did not analyze the data by field or compare them to population norms to examine possible effects of parents' educational level on women's career choices. However, comparing her distributions to Harmon's (1965) 45-50 year-old group some differences can be observed at each end of the distributions. Astin's subjects were considerably more likely to report fathers with some high school or with a graduate or professional degree than were Harmon's subjects, and the mothers of Astin's subjects had slightly higher educational levels than did Harmon's.

A pattern is beginning to emerge in these one-factor SES studies regardless of methodology, sampling, or year conducted. Different fields do attract students from different SES backgrounds, yet when SES is used as a predictor variable in a multivariable approach, its effects are washed out by more powerful factors. Differences among fields appear to be so minor as to suggest that this approach is of little practical value in understanding vocational development. Problems of methodology cloud the issue, but the most uniform effect observed is the level effect. That is, SES as a social class construct seems to be more related to level of career choice than to field.

Composite SES Indexes. Thus far we have reviewed studies which use a one-factor index of SES. Further, most studies have used college freshmen or graduates as subjects and have presented what can be called occupational-static pictures. There is considerable agreement, however, that we need prediction studies of paths of career development (Super, 1969). Cooley and Lohnes (1968) are forceful proponents of this approach and offer a most adequate discussion of its importance. The remainder of this section reviews those limited numbers of studies using this approach.

The first study to be reviewed (Davis, 1964a, 1965), while not specifically a career-pattern study, was one of the more comprehensive studies of college graduates, their backgrounds, educational paths, and future plans.

In the spring of 1961 the National Opinion Research Center surveyed 33,982 June graduates of 135 colleges and universities selected to represent all graduating students at all 4-year accredited institutions or very large non-accredited institutions granting baccalaureate degrees. Davis (p. 2, 1965) points out that the sample is: (a) representative of students, not institutions; (b) representative of June graduates only; and (c) not representative of those who started college when the respondents did but were delayed in progress or did not continue on to graduation. It is representative of those beginning college earlier whose progress was delayed so that they happened to graduate in June 1961. The data he reports was weighted to compensate for the sampling biases.

As part of an extensive questionnaire each graduate was asked to record his first major in college, his graduating major, his career preference when he started college and his current anticipated career field from a list of 99 provided in the questionnaire. To analyze the relationship between SES, college majors, and career choices Davis (pp. 206-212) used a 3-factor, binary index. Responses of: (a) family income of $10,000 or more; (b) father's education as part college or more; and (c) parental occupation as professional, manager-proprietor, sales, or clerical were scored with value 0. Responses of: (a) family income less than $7,500; (b) father's education as high school graduate or less; and (c) parental occupation as skilled, semi-skilled, service, unskilled, or farm each scored as 1. The scores were then summed for a SES index ranging from 0 to 3. The respondent was classified as low if his scores summed to 0 to 1, as high if the scores summed to 2 or 3. By establishing expected responses to majors and careers according to the total sample, he could note deviations from expectancies. Using this technique to analyze career preference at the start of college, Davis reported that the social sciences, the humanities and fine arts, medicine, and law were over-chosen by high SES students. SES had no effect on choices of the physical sciences, biological sciences, engineering, education, other professions, and business. At the end of 4 years he found some relation between SES and transfer into or persistence in a major, but the notable finding was the same composition of SES in the 10 fields as when the students began.

Davis then analyzed the relationship between a number of variables and career preference at the time of graduation looking specifically at changes in directions between the freshman and sophomore year. He found for each group: (a) for anticipated career in education a low SES makes an independent contribution; (b) for anticipated career in business SES is not related; (c) for anticipated career in social science a high SES is independently related; (d) for humanities there is a positive but small contribution by a high SES; (e) for biological sciences there is no consistent effect of SES; (f) for law a high SES is related; (g) for physical sciences a low SES is related; (h) for medicine a high SES is related, at college entry for men and women, and for attraction to and retention in the field; and (i) for engineering a low SES interacts with religion, race, and ability measure surrogate, but in general the effects are washed out by the exceptionally high defection (change from engineering as original preference) rate.

Using the same data but basing the study on those 39,726 respondents planning to attend graduate school, Davis (1964a) explored the relationships between anticipated future major field and a number of variables examined in the larger study (1965). In this analysis he reports the percentage of students in the high SES category both by individual field and by groups of fields (professions, physical science, biological science, social science and humanities). The humanities had consistently greater proportions classified as high SES. The professions had the greatest range in percentages with law and medicine highest for all fields and education at the bottom. Physical sciences were fairly well dispersed with the highest percentage being lower than the highest in all other groups. Biological sciences were more like graduate fields in general, while the social sciences were similar to the humanities with a generally high proportion of high SES students. Of course his use of a statistically induced binary SES index provided results which seem clearer than others we have reviewed.

In his earlier described study, Cooley (1963a) used what he called the "home scale" as one of six SES variables. This scale was apparently composed of information about mother's and father's type and volume of reading, hobbies, and civic activities. In the pre-high school to high school and high school to college phase of this study, he reported results paralleling those for parents' educational level and father's occupational level. That is, father's occupation, parental educational levels, and home scale are not particularly powerful discriminating factors when trying to predict career development toward science. Their major discriminating power lies in predicting plans to attend or not attend college.

Two additional studies, from Project TALENT, offer significant information about the development of young people. Like the Cooley (1963a) study, they are essentially trait and factor approaches to vocational development. The Project TALENT data to date has come from seniors in high school, 1 year after high school, and 5 years after high school. The original assessment was conducted with 400,000 students in four classes, a 5% probability sample of all high school students in Grades 9-12 in 1960. As each class was out of high school for 1 year, they were contacted, thereby yielding data for the 1 year after high school reports. The percentage of students responding to the 1-year follow-up questionnaire declined from 69% to 37% over the four years. The major analysis of data about specific career plans did not use SES as a variable except in differentiating between college-bound and vocationally-bound students (Schoenfeldt, 1966) by type of college.

The 5th year after high school survey obtained 129,827 student responses to a questionnaire designed to assess their educational and vocational status (Flanagan, Shaycroft, Richards, & Claudy, 1971). To determine student career and educational plans and activities, the respondents were asked to describe their jobs through free-response items such as "What occupation do you plan to make your life work?" Responses were later coded into a systematic structure. Respondents selected their college majors from a predetermined list. The SES variable used in the analysis came from the initial data collection (Flanagan & Cooley, 1966, p. E-10) and was a multivariate index composed of items about: (a) value of home; (b) family income; (c) books in home; (d) appliances; (e) presence of TV, radio, etc.; (f) subject had own room; (g) father's occupational level; (h) father's education; and (i) mother's education. SES and college entry were found to be related both at the 1-year and 5-year interval. Williams (1968), using discriminant analysis, found that one function could separate the agriculture, vocational, general business, and college preparatory curriculum groups. In that function the SES variable carried the fifth largest weight, indicating it was a good discriminator. SES was not used in Project TALENT to explore specific occupational plans beyond the general concern with plans for further education.

H. S. Astin, using Project TALENT data (1968), attempted to identify personal characteristics of the 9th-grade student that would predict his vocational choice in the 12th grade and to identify qualities that would predict a specific choice. As her subjects she used 650 men who were tested in 1960 as part of Project TALENT and who completed the Student Information Blank as seniors in 1963. She divided the subjects into seven categories based on expected career: (a) sciences; (b) engineering; (c) education-teaching; (d) professions, arts, and humanities; (e) other, no college degree required; (f) business and management; and (g) unclassified. The SES index described above was included as one of 26 personal variables in a multiple-discriminant analysis to determine how well the seven groups could be differentiated. Five discriminant functions were determined from the first-discriminant analysis based on the 26 personal variables. SES was a weighted variable only in the second-discriminant function which appeared to be a humanistic-thing dimension separating the professions and teaching categories from the engineers. Without more detailed data and cross validation it is hard to judge the importance of SES in the discrimination function, but it appears to be of little practical significance.

In 1970 Astin followed the same approach to study the vocational development of young women. This time she used longitudinal data from a sample of Project TALENT women tested in 1960 as seniors in high school, followed up one year later and then again in 1966. From 17,009 cases, she drew equal samples in 10 "expected" career groups (natural sciences, professions, teaching, health fields, business, arts, social service/social sciences, office work, housewife, miscellaneous). Final data analysis was based on 5,387 women. One of the three discriminant analyses which were run was based on the 13 environmental variables and resulted in three functions. SES was not consistently a major factor in contributing to the discriminations.

Entry into High School. Only one study used data from subjects prior to high school in an attempt to study SES and its relation to vocational choice expressed as a career goal or high school curriculum. Cooley (1963a) found that SES was not related to 9th grade expressed vocational choice and concluded that his SES index of parents' education, father's occupation, and a home scale would not discriminate among the prospective scientist pool, college nonscience, and noncollege-technical career groups.

Entry into a Post-high School Educational Program Leading toward a Scientific or Technical Career. A number of studies used high school curriculum choices as an index of career objective, but these were anchored to a career choice only in a very gross sense. Of those reviewed, Cooley's (1963a) was one of the most definitive. He concluded that SES was a powerful variable in differentiating between his two college-bound groups (potential scientist pool, college-nonscience) and his two vocationally-oriented groups (noncollege-nontechnical, noncollege-technical). Werts (1966b) concluded that there was a relationship between SES and a college freshman's career objectives. He found that men in the lowest four categories of SES tend to over-choose engineering among his science-related categories; men from the middle classes tended to over-choose physics, mathematics, and statistics; and men from the highest SES over-chose college professor. However, since all choices were related to father's occupation, using father's occupational level as an index of SES does not control for "inheritability" of careers. In H. S. Astin's studies (1967a & b, 1970) she concluded that SES was important in predicting the vocational choice of college men and women although her evidence is somewhat obscure. In her discriminant analysis, one function included SES as a weighted variable in separating the natural sciences, professions, social service/sciences, and teaching choices from housewife and office work for women college students. For men SES was an important variable in differentiating students along a dimension of teaching and the professions from engineering. One might conclude that SES provides limited discriminatory usefulness when analyzed in relation to other data with engineering again attracting students from the lower SES categories.

College to Graduate/Professional School or Entry Position. Major studies of careers in science have more often studied the career plans and graduation majors of college seniors than of any other group. When Cooley (1963a) explored the relationship between his four SES variables and student's future plans at 5 years after high school, he found no differences in mean SES levels among those going to graduate school in science, those going on to medical or dental school, those going into the applied sciences and nonscience groups. However, he did find that those students who had reported their father's occupation as science-related were considerably more likely to be classified in the graduate school science or applied science groups than the others.

When Harmon (1965) surveyed PhDs, he found a clear but diminishing relationship between SES as measured by father's occupation and the occupation of offspring classified in the sciences. The modal classification of father's occupation for each of his science groups was professional (i.e., highest SES) except agricultural science where farm was modal, basic medical sciences of physiology, pharmocology, biochemistry/microbiology where labor was the modal class, and engineering where labor was the modal class. A somewhat different pattern emerged when he looked at father's educational level. The modal level of education was Grades 1-8 regardless of the field for all his 30 years of cohorts except for the medical sciences where graduate school was the modal level for the 35-40 (year of degree) and 40-50 cohorts. However, in the 55-60 cohort there is an abrupt shift to the 8th-grade education as modal response. Eighth grade was modal for mothers except for medical sciences where high school graduation was modal. From this description it appears that using educational level of mother and father gives a different picture than occupational level of father as an indication of SES. Schwartz (1965) found that having a father with an advanced degree was highly related to receiving advanced training in the sciences. Her results were somewhat different from Harmon's. When Harmon compared his PhDs to their father's occupational level, a professional background was typical except for engineering, agriculture, and the basic medical sciences. Although Schwartz found more variation, her occupational level classes were of a different structure and she used field of study for highest degree in her career choice classification.

In the A. W. Astin and Panos (1969) study of college student development, father's occupation was positively related only to a vocational choice of clergyman, physician, or lawyer. In predicting the final college major, father's occupation was a significant positive predictor variable for expressed choice of arts and humanities. However, because no level was clearly proscribed in their scoring for father's occupation, their use of family income probably is a more accurate gauge of the SES conception as we are using it here. They concluded high income was related to final career choice of business or law, low income was related to engineering and education. They also found that parents' educational attainment did not improve the predictability of the student's graduating major or career choice.

When using a composite SES, Davis (1964a, 1965) concluded that SES had no relationship to choice of physical science, biological science, engineering, education, business, or other professions as a major field of study at graduation. However, SES was negatively related to career choices of education, physical sciences, and engineering while there was no effect for biological sciences and business and high positive relationship to law, medicine, and the humanities. These results suggest that college major at graduation is not an altogether adequate expression of vocational choice.

In general these studies suggest that socioeconomic status can be used to differentiate among the college-bound and noncollege-bound; before and after that transition point SES will be a discriminating variable only for distinguishing between graduating majors in engineering and in the humanities.

The studies leave unanswered the questions of why more low SES students do not enter other fields and precisely how SES effects the vocational development of young people. Perhaps vocational psychologists have not adequately defined social class conceptually or operationally to assess its effects on vocational development or have not applied sociological concepts to the observation of psychological phenomena.

Or it may well be that social class as a demographic variable is not useful in looking at vocational development. Perhaps the stimuli within each social strata which are associated with choices of scientific careers must be analyzed in more detail. This possibility will be considered in the sections on family, peers, and school as micro social systems.

Geographic Influences

In this section we review the relationship of geographic differences to vocational development of scientists and technologists. Crites (1969) has pointed out that there are sufficient differences in the belief, value, and ideological systems of the inhabitants of various regions of this country to legitimately classify regions as subcultures. It might be expected that these differences would effect vocational development. Among related hypotheses in the literature is Knapp and Goodrich's (1952) frontier hypothesis of the origin of American scientists. From their observations they concluded that the Middle and Far West produce more than their share of scientists. This stems from an attitude and value system perpetuated from the early settlement of this country—attitudes and values of pragmatism, empiricism, and an aggressive rapport with the physical elements in the environment. Knapp and Goodrich made clear, however, that these regional influences may be indirect and not distinctly visible.

Those few studies that have attempted to isolate regional origins of scientists have usually done so by surveying scientists (Harmon, 1965; Knapp & Goodrich, 1952; Visher, 1948) or superior students (Holland, 1957) to assess their undergraduate and graduate institutions (also Astin, 1963b, Harmon, 1967). The objective was not so much to determine the impact of regional subcultural influence on vocational development, but rather insitutions by their productivity of scientists. Consequently, these studies are not strictly relevant to this section.

In looking for evidence that vocational choices vary among regions by age of students only two sources of data were available. The American College Testing Program collects and reports student data while conducting its national test program. The 1966 edition of *College Student Profiles* (ACT, 1966) contains extensive normative data about college-bound students. The norms are presented by region of the country and level of educational institution in which the college freshmen are enrolled. The sample consisted of 232,230 students who entered 100 colleges, universities, and community colleges in the fall of 1965. There are regional biases in the data, however, with the most reliable data coming from the Midwest, Rocky Mountains—Plains, and part of the South. The data are not as representative of college freshmen in the Northeast, the extreme Northwest, and the Southeast. Nevertheless, when comparing the vocational choice as the best description of future vocation and probable college major by region, little difference is observed. Seven percent of the students on the West Coast chose a science major, while 12% chose engineering, agriculture, and technology. Comparable figures for the Mountain-Plains are 7% and 13%, for the Southwest 6% and 11%, for the Midwest 8% and 12%, for the Southern region 7% and 13%, and for the Northeast 9% and 11%.

When looking at the student choices of future vocations, we find 3% of the West Coast students selected science and 10% selected engineering, agriculture, and technology careers. Comparable figures for the Mountain-Plains region are 3% and 11%, for the Southwest 3% and 11%, for the Midwest 3% and 11%, for the Southern region 4% and 11%, and for the Northwest 3% and 9%. While the biases in the data sources prevent a definitive statement about differences, the data do not suggest any major differences in major or vocational choice by region of the country.

It is possible that the gross categorization of fields in the ACT data masked differences by region. Data collected by the American Council on Education helped determine the plausability of the hypothesis. The Office of Research at ACE (A. W. Astin, Panos, & Creager, 1967) surveyed 206,865 first-time freshmen entering 251 institutions in the fall of 1966. The data were weighted to make them representative of the population of college entrants that fall. Each student was asked to indicate his probable major and career occupation which were categorized in 17 and 15 classes, respectively. The data were then organized into four regions by college location (East, Midwest, South, and West).

Some marked differences appeared in probable major. Among students from the East, 4.8% indicated a choice of biological sciences compared to 3.3% for the Midwest, 3.7% for the South and 3.2% for the West. More engineering majors came from the East—12.2% as compared to 7.7% from the Midwest, 10.7% from the South, and 9.6% from the West. Students from the East were more likely to choose mathematics or statistics—6.9% as compared to 4.5% from the Midwest, 3.8% from the South, and 3.1% from the West. The students from the East were also more likely to indicate a major in the physical sciences—4.5% as compared to 3.1% from the Midwest, 3.0% from the South, and 2.6% from the West. Social science majors were more likely to come from the South—8.6% compared to 7.5% from the East, 8.4% from the Midwest, and 8.3% from the West. Those students in technical majors were more likely to come from the West—3.1% compared to 2.2% from the East, 1.9% from the Midwest, and 1.8% from the South. In each case, except for the social sciences and technical majors, the East was the modal source of students. The West contributed the fewest in the biological sciences, mathematics or statistics, and physical sciences, while the Midwest produced the fewest engineering majors and the South produced the fewest technical majors.

The dominance of the East was clear in expressions of probable career. For college professor (2.4%), engineer (11.4%), and research scientist (4.7%) the East was the modal classification of the college's geographical location. The South yielded the fewest research scientists, and the Midwest yielded fewest engineers. The Midwest, South, and West had equal percentages (1.6%, 1.8%, 1.6%) of future college professors.

Although it would be helpful if we could be certain of the origins of the students (Baer, 1962) rather than the institutions, the ACE data does support the hypothesis that there are regional differences in vocational development of scientists. The precise nature of the regional stimuli which are associated with the differences is yet to be established.

Religion

How might religion affect the vocational development of scientists and technologists? The obvious answer is the difficulties some have in reconciling their scientific and religious views of the universe. There is some evidence that religion is related to SES (Goldstein, 1969) until the occupational and educational levels are parceled out to eliminate differences in SES among Protestants, Catholics, and Jews. Although Goldstein attributed the differences to educational and occupational effects, it also implies that occupational and educational levels are related to religious background. Of course such a conclusion is not unexpected given the evidence of the inheritability of occupations (Werts, 1966a & b, 1968).

Actually, we know very little about the effects of religious beliefs and practices on the vocational development of children, adolescents, and young adults who are moving toward science and technology. Virtually all research found regarding the religious background of scientists used data from students already in college or scientists already on the job.

Although some of the early studies of eminent scientists, e.g., Visher (1948), generally gathered some scant data about religious backgrounds, the most fruitful research has come from some frequently cited studies.

In Davis' (1964a, 1965) study of Spring 1961 college graduates, he asked his subjects to record the religion in which they were reared as well as their current religious preference. Protestant, Roman Catholic, Jewish, "other", and "none" were the categories offered and the respondents were asked to indicate specific Protestant and "other" choices. He determined the relationship between religious background and (a) recalled career choice as freshmen, (b) career choice as a graduate, (c) changes in career choices for all students (Davis, 1965) and for those going on to graduate or professional school (Davis, 1964a).

He reported that those from Roman Catholic backgrounds over-chose physical science, law, and business; and under-chose what were classified as "other professions," e.g., dentistry, nursing, optometry, agriculture, library science, as entering students. At the same time freshmen from a Jewish background over-chose social science, medicine, and law; and did not over-choose any other field. Protestants over-chose education and under-chose physical science, social science, law, and medicine. The biological sciences, engineering, the humanities, and fine arts were neither under-chosen nor over-chosen by any of the three religious categories.

Davis also examined the relationship of career choices as graduating seniors to religious background. He concluded that religion was not related to education as a senior-year career choice. Jews were over-represented in the social sciences and law, Catholics were over-represented in law, Protestants under-chose physical sciences while Catholics over-chose it. Protestants under-chose medicine while Jews over-chose it; the humanities and fine arts, the biological sciences, and engineering were independent of religious background. In summary, career choice as a freshman and career choice as a senior were similarly related to religious background.

When he analyzed the religious backgrounds of only those going on to graduate or professional school (Davis, 1964a) the modal religion was, as expected, Protestant. Again without presenting additional data, it is difficult to substantiate a hypothesis that religious background was related to graduate field of study. But he concluded that:

> The relatively Protestant fields are mostly sciences—zoology, biology, botany, earth science, along with other professions—while all the humanities and social science fields are less Protestant than graduate students in general, as are law, medicine, and biochemistry. Biochemistry stands out, along with law, business, economics, and philosophy, in the proportion of Roman Catholics, while zoology, botany, earth sciences, other physical sciences, and art have a relatively low proportion of Catholics. These figures challenge any unqualified assertion that Catholics opt for humanities and are less interested in sciences. Jews tend disproportionately to choose medicine, clinical psychology, and law, patterns that are not surprising. However, save for nursing, botany, and zoology, there do not seem to be any "non-Jewish" fields when graduate students are considered.

A. W. Astin and Panos (1969) used religious background as a variable in their multiple-correlation approach to predicting career choice and field of study of graduates from freshman data. Parents' religion (Jewish) entered the prediction equations with a significant F-ratio only for the non-MD health professions and physical scientist fields of career choice, and was an important predictor in final major of education while being Catholic was highly negatively related. They concluded also, that students were likely to remain oriented toward medicine and law if their parents were Jewish, and that students with Catholic backgrounds were less likely to enter education either as freshmen or be attracted to it during their college career.

Snelling and Boruch (1972) presented data on science graduates of 49 selective colleges. The 20,833 graduates of the colleges between 1958-1967 were sent a six-page questionnaire of which 16,395 were returned. Although the study did not examine the relationship between religion and ultimate career choice, it did examine the relationship between religion and area of specialization. The unique feature of the report was the categories of religious background used: agnostic, atheist, Catholic, Jewish, Protestant, other. Five categories of majors were used: biology, chemistry, math, physics, and premedicine. Physics attracted the greatest proportion of students from agnostic backgrounds (10.5%) and atheistic backgrounds (3.8%). Premedicine attracted the greatest percentage of students from Jewish backgrounds (13.4%) while biology was their next most frequent choice (10.4%). Protestant backgrounds were virtually equally represented in biology (65.2%), chemistry (66.1%), math (68.5%), physics (64.3%), and premedicine (67.4%). Catholic backgrounds were also equally distributed (biology 8.9%, chemistry 9.0%, math 9.3%, physics 8.8%, premedicine 7.5%). Snelling and Boruch also reported trends between 1958 and 1967 in religious backgrounds for their respondents. They reported that Protestant background declined by about 5% while Jewish background increased by a like percentage.

Despite the differences in methodology the pattern of results reviewed suggests that religious background is related to the career choice of science. Jewish offspring tend not to go into science in the same proportions that they go into law and medicine, and those who do enter the sciences tend to choose a medicine-related course such as biology or chemistry. Protestant and Catholic offspring tend to be equally represented in all the sciences.

Community

In his review of correlates of vocational development, Crites (1969, pp. 229-230) used the term "community" to describe research on micro social systems of peer groups and ethnic groups. In this report we depart somewhat from his schema by using community to include those studies which investigated differences between rural and urban residence on the vocational development of scientists and technologists.

Much of the work in the differential effects of community size and residence location on vocational choice has been done by sociologists. The term aspiration is extensively used while the term vocational development is rare. Vocational psychologists may have overlooked the work of sociologists in vocational development because of their lack of explicit subscriptions to theoretical developments in vocational psychology although this is not universally true, of course, see Cosby and Picou, 1971.

In general, sociologists' use of the term "aspiration" differs somewhat from ours. in the following studies aspiration generally refers to the prestige of an occupational goal. The higher the prestige of an occupation (Roach, Gross, & Gursslin, 1969), the higher the aspiration ascribed to the subject. Responses of the subjects are generally classified into the Bureau of the Census system or ranked according to some scale and relationships to SES, residence, and the like are determined. The usefulness of the sociological studies is limited by their lack of specificity of fields within the prestige ranking of occupations as criterion variables. Thus, the use of Bureau of the Census classifications (professional, technical, and kindred workers, proprietors-farmers, wholesale and retail, other, clerks and kindred workers, skilled workers and foremen, semi-skilled, unskilled) or other systems like the North-Hatt (1947) scale mask some important information. However, scientific occupations tend to be rated high in the prestige scales and both scientific and technical work are classified as professional, the highest level.

The rural-urban classification typically involves size of town (Sewell & Orienstein, 1965) or place of residence as farm, village, or city by population size. In general, it is possible to conclude that rural and urban youth have different levels of occupational and educational aspirations (Burchinal, 1961; Grigg & Middleton, 1960; Haller & Sewell, 1957; Middleton & Grigg, 1959; Sewell, 1964; Sewell, Haller, & Straus, 1957; Sewell & Orienstein, 1965; A. Wilson, 1959). Young people from rural areas or small towns aspire to lower prestige and lower-paying jobs than do youth from urban areas and cities. These differences hold when sex, SES, and ability levels are held constant (Sewell & Orienstein, 1965) even though they diminish.

Davis (1964a, 1965) in his previously discussed study of college graduates examined the relationship between size of hometown during high school days and undergraduate and graduate career decisions. He reported that senior-year career choice of physical science, social science, humanities and arts, medicine, and law were over-chosen by students from larger cities, resembling SES relationships, while only engineering, business, and biological sciences as choices were not related to size of community. Education was under-chosen by respondents from large cities. He found that as size of hometown increased, there was a corresponding increase in the proportion of students going on to graduate or professional school right after receiving the BA, with 23% of the students from rural areas continuing while 45% of those from metropolitan areas expressed the same plan.

However, when the data were classified by a central city-suburban dichotomy, no major differences were observed in plans.

The parallel between the relationship of SES and graduate field of study and size of hometown and graduate field is striking. However, several interesting observations can be made. First, biology and botany were much more likely to attract students from farms or smaller communities of 10,000 or less than were any other sciences. Engineers, generally from low SES categories, typically came from either farms, small communities or cities of 500,000-2,000,000. It should be noted, however, that going to graduate school in engineering is a fairly rare occurrence. Thirty percent of graduate students in general came from small towns while 40% of the biologists and 52% of the botanists did. Are the patterns different enough to identify differential effects on vocational development of scientists? Probably not without studying other factors. There are differences, but the overlap suggests that various stimuli may interact to produce scientists from different communities and they may be common or different according to SES, community and vocational development.

Racial and Ethnic Background

The racial and ethnic backgrounds of scientists and future scientists constitute our final macro social system. Again, we encounter the problem of overlap of social systems producing interaction effects with vocational development.

Emphases in the study of the ethnic and racial background of scientists have varied over the years. Early in the history of the study of scientists (Terman, 1954; Visher, 1948), the emphasis appeared to be on genetic kinds of relationships. Later the concern focused on the brain drain (Harmon, 1967). Recently more interest has been expressed in the subcultural effects on development of young people in conjunction with social concern over equality for minorities (Haber, 1966).

Visher (1948) reported the results of a survey of 2,607 eminent scientists. A little less than one-third of his respondents were of what was called Puritan stock followed by other English, German, and Scottish. Comparing his findings with Cattell's (uncited) he found a decline in the Puritan stock and an increase in German and Jewish.

Dole and Sherman (1964) have reported the results of a study of 9th-grade males' choice of a science program. Their experimental group consisted of 1,009 boys and their control group of 3,659 boys who were about to enter high school in Hawaii. The subjects were asked to select from five curriculum programs (college-preparatory scientific, college-preparatory general, technical, business, and terminal) the one they would like to take in high school. The experimental group was those who chose the college-preparatory scientific curriculum. Although other variables were reported as being more important predictors of curriculum choice, Dole and Sherman stated(p.101), "The science boys were more likely to be of Japanese ancestry and less likely to be of Hawaiian or Filipino ancestry . . ." Because of the large sample size, a Chi-square test of independence probably would have been significant when comparing the distribution of ethnic backgrounds by curriculum choice. Differences were calculated by subtracting the particular response percentage for all students from the percentage for that response among those choosing science. For ethnic background differences were: (a) Caucasian +3%, (b) Chinese +1%, (c) Hawaiian -4%, (d) Filipino -8%, (e) Korean 0%, (f) Japanese +17%, (g) other -3%, and (h) mixed -6%. The students were also asked who the first member of their family was to enter the U.S. and the differences in percentages were: (a) father -3%, (b) grandfather +14%, (c) greatgrandfather +3%, (d) don't know -10%, and (e) doesn't apply -4%. Living in Hawaii, having a Japanese heritage, and being a second- or third-generation resident of the U.S. seems to differentiate among those planning on a college-preparatory science curriculum. In their earlier study (Sherman & Dole, 1961) of 6th-grade science boys, differences in national-ethnic origins were also found.

Sprey (1962) examined differences between occupational choice patterns of black and white students in two Northeastern cities. He hypothesized that the blacks shared occupational and educational aspirations with whites, that blacks have lower expectations than whites, and that blacks show a less ambitious pattern of enrollment in various high school curriculums. His samples consisted of 1,154 9th graders in New Haven and 1,442 9th graders in Harrisburg with a total of 533 black subjects. Differentiation between aspiration and expectation was made when eliciting occupational choices from the students. Each of the major analyses was conducted in a mobility framework with aspirations and expectations classified in a three-way system of occupational levels using white collar, skilled-manual, and lower manual. The occupational levels of the subjects' fathers were similarly classified and compared to the aspirations and expectations of offspring. Sprey found that black boys had significantly lower aspirations than the white students and black girls. The aspirations of the girls were higher than the boys regardless of race, but the difference between the levels of aspiration of black girls and boys was sizably larger than the difference between the aspiration levels of white girls and boys. There was also a relationship between aspirational level and level of father's occupation—the lower the occupational level of the father, the greater the aspirational level of the student. In a separate analysis he looked at those "undecided students" and found that black boys had the highest proportion of "undecided" responses, particularly if the father's occupation was classified as lower manual. The girls of both races had fewer "undecided" responses than the boys. When comparing expectations with father's occupation for the Harrisburg sample (the appropriate data were not available for the New Haven sample), the results were parallel to aspiration. Girls had higher expectations than boys and the difference between the levels of measured expectation of the black sexes exceeded the differences of white subjects. As in other studies there was a difference between expectation and aspiration with the level of expectation being generally lower than aspiration. He also found that black males were less likely to enroll in the college-preparatory curriculum.

Three members of the Department of Counselor Education at New York University obtained results contrary to Sprey's when they studied the relationships among race, sex, and social mobility as measured by occupational aspiration and expectations of high school students in four different cities in New York (Pallone, Rickard, & Hurley, 1969). Pallone, Rickard, and Hurley concentrated on youth from the lower and lower-middle SES by using subjects in schools serving those populations in a megalopolis (New York City), middle-town (Elmira), Exurbia (Patchogue), and Capital City (Albany). Each school district identified an appropriate school building from which a total of 531 students were sampled of which 240 were black. Although they intended to focus on lower and lower-middle class students, when they classified the head of households' occupation into SES categories, they found their sample consisted of upper-lower and lower-middle class students. Similar to Sprey and others cited in this section, they asked their subjects to indicate in a free response format the job they would like as a fully-grown adult and what job they expected to have as a fully-grown adult, both of which were then classified by an occupational prestige scale. Using a three-way analysis of variance involving sex, race, and urban configuration, Pallone, Rickard, and Hurley found that males held higher levels of aspiration than the female subjects, blacks aspired to higher status occupations than whites, and aspiration differed according to race and city. The students in Exurbia had higher aspirations than those in the other cities, and the blacks in Exurbia, Capitol City, and Megalopolis held higher aspirations than whites. They also reported (p. 7) "The highest mean occupational aspiration level is noted among black females in Exurbia, whose aspirations on the average are toward upper class occupations, while the lowest mean level is noted among white females in Megalopolis." Almost identical results are reported for occupational expectations, except that expectations are lower than aspirations. Again blacks expressed higher expectations than whites, and subjects in Exurbia held higher expectations than subjects in other cities. The relationships among race, aspiration, and expectation appeared to be related to SES. There were significant differences by race within city and among the cities in mean SES scores. Blacks in all four cities had lower SES mean scores than whites even in the Megalopolis where SES was highest among all the cities. The conflicting results of this study and Sprey's study may be the consequence of sampling and measurement of SES; nevertheless, the results are contradictory.

Antonovsky and Lerner (1959) compared the levels of occupational aspirations of 16- and 20-year-old black and white youths in a small town and found a higher level of aspiration for the black students. In a replication of the study in a metropolis (Antonovsky, 1967) with 378 10th-grade students in five city high schools, a similar pattern was found. Middle class whites expressed the highest aspirations while the lower class Puerto Ricans expressed the lowest. Moreover, Antonovsky found no differences in aspirations or expectations among lower class whites, middle and low class blacks, and middle class blacks. Stephensen (1957), and Gist and Bennett (1963) found like patterns of higher educational and occupational aspirations for black youths than for white youths, but these studies reported lower levels of expected occupations for blacks than for whites. Hindelang (1970) attempted to clarify the relationships between race and occupational aspirations. His sample consisted of 187 black, Mexican-American, and white 4th-, 5th-, and 6th-grade students on the West Coast. Their occupational aspirations were assessed in interviews with counselors of different ethnic-racial backgrounds. He found no significant differences in levels of occupational aspiration, but did find significant differences in educational aspiration. Blacks were highest, whites second, and Mexican-Americans lowest in aspiration.

While these and other studies (Uzel, 1961) are relevant to this report only to the extent that movement toward a career in science probably requires high educational and occupational aspirations, an American Council on Education study provides more pertinent data. Boyer and Boruch (1969) studied black students in American colleges. The report was based on ACE's Student Information Form administered to 301,000 freshmen at 435 colleges in the fall of 1968. The institutional samples were selected from a stratified population so that weighting of the data was necessary to insure that it reflect the population. Students recorded their race and sex and selected their probable field of study from among 66 fields listed. To establish national norms the colleges were classified by type and racial composition into 2-year predominately white, 4-year colleges predominately white, 4-year colleges predominately black, and 4-year universities which all were predominately white. The records of 12,300 black students were compared to data from 230,582 nonblack students. There were major differences in probable majors by race in two science fields: engineering and social sciences. For men in all institutions regardless of type almost twice as many nonblack students (17.4%) as black students (9.4%) indicated that they would enter engineering. Four percent of the nonblacks said they would enter the physical sciences while 2.6% of the blacks gave the same plans. On the other hand, twice as many blacks (10.4%) indicated they planned to major in psychology, sociology, or anthropology as did nonblacks (5.1%). The differences in other science related fields of study were very small. Few men expected to be research scientists (2.9% of the black men and 3.8% of the nonblack men) while the differences for those looking to engineering were larger (8.8% black men, and 14.8% nonblack men).

The norms for women show that 18.3% of the black women plan to major in the social sciences while only 11.5% of the nonblack women gave this response. More nonblack women (4.2%) than black women (3.4%) planned to major in mathematics or statistics while equal proportions anticipated a major in the biological and physical sciences. Equal proportions (1.7%) of black and nonblack women expected to enter the world of work as research scientists.

Fichter (undated) reported the results of a 1964 survey of samples of graduates from 50 predominately black colleges. Data were obtained from 907 men and 1,483 women for a 45% and 53% response rate, respectively. The data were appropriately weighted to reflect the predominately black college population, 1.7% of the respondents were whites and 0.6% indicated other races. Fichter then compared his data with those of the National Opinion Research Center survey reported by Davis (1964a, 1965) for graduates of predominately southern white colleges (PSW) and "all other graduates" which excluded both PSW and those from predominantly Negro colleges (PNC). When anticipated career fields were compared, twice as many graduates—5% of the men and 10% of the women—from predominately Negro colleges indicated social work than did graduates of PSW (1% men and 5% women) or "all other graduates" (1% men and 4% women). The differences in percentages of graduates selecting the physical sciences were very small. Nine percent of the men in the PNC and PSW groups selected the physical sciences while 3% and 4% of the women expressed this expectation. Eight percent of the men and 2% of the women in the "all other graduates" category selected a physical science field. As in other studies cited in this section, half as many male graduates from PNC schools (8%) selected engineering than did men from PSW (16%) and among "all other graduates" (13%). Slightly more, 2-3%, of the men and women graduates of PNCs opted for the biological science and social science jobs than those in the PSW and "all other graduates" categories. Thus, graduates of PNCs were more likely to enter the social sciences and education than were other graduates while they did not express interest in engineering and business in the same proportion as did other students. Since comparisons were made with predominately Southern white college graduates as well as all others these cannot be considered solely regional differences.

When he reviewed aspirations as indicated by degree objectives of going directly to graduate school, Davis found major sex differences, but little by location, type of school, or by highest degree expected. He estimated that 29% of the graduates of PNCs would go on to graduate school compared to 37% of the PSW group and 45% of the "all other graduates." More men from PNCs (71%) planned to receive their master's degree than did those from PSWs (57%) or among "all other graduates" (62%). Fewer of the PNC sample men were going on to the professional degree (23%) as compared to the PSW (34%) and "all other graduates" (30%); a similar pattern was observed for those going on to the doctorate (PNC=20%, PSW=25%, and "all other graduates"=25%). Far fewer of the women graduates planned to go beyond the master's degree, but the differences in percentages by type of college were relatively small. Three percent more of the PNC than PSW women were planning on the master's degree, while only 2% more of the latter planned on the master's than of all other graduates. Nine percent of the women in both the PSW and PNC group hoped to obtain the professional degree while 6% of the women in the "all other graduates" category had this objective. Of the women graduates of PNC, PSW, and "all other graduates" 16%, 17%, and 14%, respectively, were planning to obtain the doctoral degree.

An examination of anticipated field of graduate study by race, sex, and group reveals patterns similar to those for vocational choice. More PNC women (9%) were planning on additional training in social work than were women from PSW (5%) and "all other graduates" (4%). Four percent of the PNC men were going into social work training while 1% of PSW and "all other graduates" were. The physical sciences were attracting an approximately equal proportion of graduates within sex and group. Again twice as many non-PNC men graduates were going into engineering as were the PNC men graduates. Six percent more men in the PNC group (10%) were entering postbaccalaureate training in the biological sciences than were men in the other groups (4%). Almost equal proportions of each group were going into the social sciences.

While clear differences have been found, the studies are not able to determine whether what is observed is a pure race effect, an SES effect, a school effect, or an interaction effect on vocational development. Bayer and Boruch's (1969) results are used to isolate school effects, there doesn't appear to be any differences in occupational choice or college major patterns by race and college type other than those already presented. Perhaps there is a major SES effect as yet undocumented. The lower SES levels of minorities in this country may influence offspring to select the social sciences and services, while not deflecting them from the natural and physical sciences. For example, minority offspring are not enamored of engineering at any stage of their development to the degree that comparable white students are. There seems to be growing evidence of a race effect, but only in certain fields.

From this review of the effects of macro social systems on the vocational development of scientists and technical workers we see that while there are relationships between expressions of vocational choice and SES, geographic region of origin, racial and ethnic background, and religion, the research does not provide definitive understanding of those relationships. It may be that the use of rather gross categories of stimuli has masked rather than clarified existing relationships. The operational definitions of social class used in the studies reviewed guarantee observed differences; if there were none, the social systems could not be differentiated. Hopefully, studies of the macro social systems of stimuli, what Crites (1969) termed the immediate environment, will add new insights.

The Immediate Environment

Stimuli in the immediate environment include those physical events in the perceptual field of an individual which are present for a sufficient length of time to allow a possible relationship to vocational development. We are concerned both with the properties of the stimuli and the relationship between the properties and vocational development. The family, the school, and peer groups serve as organizing titles for our review.

Family

The family is a particularly significant reference group until adolescence (J. S. Coleman, 1963; Sebald, 1968). Several times research studied the families of scientists. One group comes from Roe's (1953) theory of vocational choice and is concerned with parent-child relationships. Another is similar to the SES research reviewed earlier on the inheritability of occupations while others concern parent-parent relationships and birth order. Within each type we find two basic approaches to analyzing the effects of the family on the vocational development of scientists. The first is typical of those early studies of scientists (Eiduson, 1962; Roe, 1957b) which were more clinically oriented; the second is more empirical.

There has been some historical congruence between the technical developments in vocational psychology and the study of the career development of scientists. One of the early major contributors to the field was Roe (1957a) who developed a theory of vocational development as a result of her studies of eminent scientists (Roe, 1952b; Roe & Siegelman, 1964). Hers is one of the few attempts to provide theoretical formulations of the relationship between parent-child relationships and vocational development. In essence the theory proposed that there were two major work or personality orientations, toward persons and away from persons; these she attributes to the child-rearing practices of the parents. Roe (1957a) proposed that there were three identifiable parent-child relationships: (a) emotional concentration with two expressions of concentration—over-protection and over-demanding, (b) avoidance of the child with two expressions of avoidance—emotional rejection and neglect, and (c) acceptance of the child with two expressions of acceptance—casual and loving. The model of vocational development prescribed that emotional concentration through either expression would be related to vocational development toward service, business contact, organizational, general cultural or artistic, and entertainment kinds of occupations as described in her classification schema (Roe, 1956). A child from an avoidance environment would move toward science or outdoor vacations, while parental acceptance could lead to either technological or outdoor occupations. This overview of the theory provides some framework for the reviews to follow.

After reviewing research available up to 1968, Osipow (1968) concluded (p. 33), ". . . the evidence is very strong against the likelihood that Roe's theory as originally proposed is an adequate representation of the crucial features of vocational development." He based his conclusion on a number of studies. Grigg (1959) found no difference between 24 graduate nurses and 20 women graduate students in chemistry, physics, and mathematics in recalled parental attitude toward them on Roe's dimensions. In another test of Roe's theory Hagen (1960) reviewed extensive data from 245 participants in the Harvard Study of Adult Development and concluded that the theory had little validity perhaps due to other more pervasive influences on vocational development such as mother-child relations or child's response to the home atmosphere. The same pattern of results was found by Switzer, Grigg, Miller, and Young (1962); Utton (1962); and Green and Parker (1965). Rather than finding general or specific support for Roe's theory, several did observe differences in parental attitudes that did relate to occupational choice or interest. For example, Green and Parker observed that the influence of fathers on their daughter's occupational orientation seemed stronger than the mother's. Switzer et al. observed that the magnitude of the difference in mother's and father's attitudes was predictive of occupational choice. They were contrasting ministerial and theological graduate students and chemistry students' perceptions of parental attitudes through the use of a questionnaire. Their questionnaire elicited different descriptions of attitudes ascribed to mothers and fathers. For example, fathers of the ministerial and chemistry groups were perceived as being more over-demanding and rejecting than mothers. They also reported that ministerial fathers were more over-demanding and rejecting than the chemistry fathers. However, the mothers of ministerial students had lower over-demanding and rejecting scores than did the chemistry mothers, indicating an interaction effect of sex of parent with college major. This suggests that if the father is over-demanding and rejecting and the mother is not, the son is more likely to enter ministerial school than major in chemistry. Of course the failure to find any major support for Roe's theory does not mean there is no connection between the nature of parent-child relations and vocational choice. For example, Roe and Siegelman (1964) found some support for a reformulation of the original theoretical structure.

Aside from those investigating the efficacy of Roe's theory, little work has been done on the parent-child relationship as it affects vocational development. The adolescent period has been the province primarily of sociologists studying aspirational levels. Again, assuming that a high aspirational level of occupation or education as a youngster is related to development toward science (Eiduson, 1962; Super & Overstreet, 1960), these studies are relevant.

When Kahl (1953) reported that some boys from a working class background aspire to middle class occupations and others do not, two hypotheses were offered to explain the differences (Simpson, 1962). One, that the occupational aspirations were a function of parental influences or, two, that peer-group influences prevailed. Simpson set out to investigate the relative impact of parents and peers. Using responses to questionnaires from 743 white high school boys, he classified the students into four categories as a function of their father's occupation's prestige, their high school curriculum, and the prestige of the occupation they expected to enter. The four classes were: (a) ambitious middle class, (b) unambitious middle class, (c) mobile working class, and (d) nonmobile working class. He reported that 53.1% of the ambitious middle class, 21.0% of the unambitious middle class, 43.5% of the mobile working class, and 16.0% of the nonmobile working class boys were advised by one or both of the parents to enter a profession. He also found that among the working class boys those that were mobile had middle class friends, while unambitious middle class boys had working class friends. Thus, he concluded that both peers and family pressures influenced aspiration level.

To determine the relative importance of family versus friends he reclassified his subjects according to the congruence between family advice and their friends' within level of father's occupation and again looked at differences in levels of aspiration. He found that when both sources of influence were high (i.e., held high aspiration for subject or for himself) 71.4% of the boys from working class backgrounds and 81.9% of the middle class boys were aspiring to a professional occupation. When both were low, 25.6% of the working class and 30.1% of the middle class boys were aspiring to professions. But the most interesting effects occurred in the absence of congruence. When working class parents held high aspirations for their offspring, and their friends had low aspirations, 55.6% of the working class boys aspired to high status occupations as compared to 35.7% of the boys from the same backgrounds whose friends had high aspirations and whose parents had low aspirations for them. The same difference in direction was observed for the middle class boys. Thus, he concluded family influence was greater and that under the congruence conditions, the negative effects of social class background on aspiration was overcome.

Simpson did not differentiate between the influence of the mother and father and a number of other influencing persons outside the family, but Ellis and Lane (1963) did. In their interview study of 194 freshmen who entered Stanford in the fall of 1958, they asked their subjects to indicate the nature and import of different persons' influence on their attendance at college, their choice of a major, and their postgraduate plans. They related the responses to the prestige of the student's father's occupation. They found that for males the frequency with which the father is named as an important influence on going to college declines as social class declines (100% for higher to 73% for lower class males). When the most important influence was identified, only 19% of the lower class students named the father, while 51% of the sample of all freshmen did. For students in general, the father was perceived as the most important influence in attending college, while in the lower classes, the mother's influence is more important perhaps because the mother's educational level for lower classes is typically higher than the father's. They found also that for lower class students, influences outside the family tended to be more important in college attendance patterns than for upper class students, with girls particularly placing more emphasis on extra-family sources of influence. When indicating "important" influences, a teacher was the most frequent nonfamily response and was rated above school friends for every class of students except males from the highest social class. Peers were reported to have less influence on college attendance patterns than either parents or teachers. There was no relationship between social class and source of influence in choosing a college major even though 43% of the freshmen cited a parent as being important and 39% cited a high school teacher. High school friends were less often cited as important influences in choice of major than any other source except "other adults."

Herriott (1963) tried to quantify relationships of parent-child and subject-other to level of aspiration by dimensions of expectation and self-assessment. Herriott's concept of "self-assessment relative to others" is similar to Super, Starishevsky, Matlin, and Jordaan's (1963), Tiedeman and O'Hara's (1963) and others use of self-concept. By comparing himself to reference groups, the young person perceives his similarity to them and sets his aspirational level accordingly, i.e., differentiates between himself and others through social interaction and reality testing. A second influence on his aspirational level is the real or perceived expectation of significant others in his life.

Herriott (1963, p. 164) proposed seven factors of self-assessment—intellectual motivation, intellectual ability, intellectual performance, economic motivation, economic performance, social performance in school, and social performance outside school—and 11 sources of expectations—father, mother, older sibling or relative, friend of same age, friend of few years older, junior high counselor, senior high counselor, junior high teacher, senior high teacher, adult friend of the family, and some other adult. He then identified eight levels of educational aspiration ranging from leaving high school before graduation to advanced study. The levels were used to test three hypotheses: (a) positive relationship between self-assessment level and educational aspirations, (b) positive relationship between level of expectation of others and educational aspirations, and (c) positive relationship between level of expectation and level of educational aspiration when holding self-assessment constant. The data used to test these hypotheses came from 1,489 adolescents in one public high school in Massachusetts. Each student rated himself in terms of self-assessment, gave his educational goals, ranked the expectation sources in terms of their value to him, and recorded the perceived educational expectation each source had for him.

The analyses produced multiple- and single-order correlation coefficients of sizable magnitude. The strength of the relationship between the seven self-assessment factors and level of aspiration was measured as a .761 multiple-correlation coefficient. The single factor with the strongest zero-order relationship to aspiration was intellectual performance (.707). The relationship between perceived expectations and aspirational level was even higher at .894. In this analysis the highest zero-order relationship between level of expectation and aspiration was for a "friend of the same age" (.821), with mother (.797), father (.784), and older friend (.795) only slightly lower. The lowest correlation was with junior high counselor (.670). The most valued sources of expectation had the highest relationship to educational aspiration when self-assessment was held constant. To determine the relative order of relationship among the 18 predictor variables and the level of educational aspiration, Herriott computed two 17-order partial correlation coefficients for each independent variable. The expectation of a friend of the same age (.248), the senior high counselor (.158), and his self-assessment on intellectual performance (.145) had the highest partial r's, for parents it was .129, and the multiple R was .901. Thus, three sources of expectation and one self-assessment factor were more important than parental expectation in influencing the level of educational aspiration.

Cohen (1965) concentrated on parental influence on college-attendance patterns as an aspiration-related variable. She matched 49 junior and senior high school boys from a working class background on intelligence and community, and interviewed their parents in order to test some predictions. She hypothesized:

1. The higher the status of the father's job the more likely was the son to plan to go to college.
2. The higher the status of the mother's job, if she had one, the more likely was the son to plan to go to college.
3. The more closely the parents identified with the middle class the more likely the son was to plan to go to college.
4. If the mother came from a white-collar family, the more likely was the son to plan to go to college than if the mother came from a blue-collar family.
5. If the father expressed dissatisfaction with his job, the more likely was the son to plan to go to college than if the father was satisfied.

In each case the prediction was upheld. Cohen also identified overt parent behaviors which could be called pressure to attend college or seek middle class occupations such as value placed on college education or reaction to poor report cards. These indicated two kinds of pressure—vocational from the father and status from the mother. Consequently, although the precise nature of the pressure from parents was not related to Roe's model, there was evidence that, as others have posited, mothers and fathers may have different influences on the child's vocational development.

The importance of parental influence on level of aspiration has also been illustrated by Harris (1970), Rehberg and Westby (1967), Kraus (1964), Bordua (1960), and Hollister (1969). However, the research does not yield definitive relationships with choice of a scientific or technological career, because by the time a student is a senior we expect him to be occupationally directed beyond the college attendance decision. Yet since for males, going to college is related to a general science interest, aspirational level may be more related to a scientific career orientation than it first appears.

Smith (1963) asked 9,967 freshmen students in 23 engineering colleges what or who from among choices of teacher, family, friend, school counselor, availability of scholarship, or other—which included personal interest, military experience, job experience, job opportunity, contacts in engineering, reading, previous school choice, financial return, aptitude-hobbies, preference for math-science, ability and other—influenced them most in entering engineering. He reported responses by eight regions of the country because there were marked differences if the modal response category was ignored. "Other" was the modal category in every region of the country with 44.7% of the responses. Overall one-fourth of the students reported the family as most influential with a range in percentage from 35.6% of the students in the eighth region (Colorado State University and Texas A & M University) to a low of 18.3% in the first region (University of Maine, MIT, and the University of Vermont). A teacher was more frequently named as a source of influence than the school counselor—12.1% and 5.5%, respectively. A friend was also considered more influential than the counselor (10.0%). So as in Ellis and Lane's (1963) study, teacher again appears as an important source of influence on vocational development.

In the earlier mentioned study, Cooley (1963a) used three variables in an attempt to discriminate among his four groups (Prospective Scientists Pool—PSP, College Non-Science—CNS, Non-College Technical—NCT, and Non-College Non-Technical—NCNT) which are related to family expectations and stimuli in the home. He ascertained the mother's and father's aspiration level for their sons and their expectation of their son's education. There were significant univariate F's when the means of the four groups on each variable were compared. However, the parental expectations had a stronger relationship to criterion group membership than did the SES variables of father's education, mother's education, and father's occupation or parental aspirational level for son. When he reclassified his college graduates into four groups (graduate school in science—GS, medical and dental school—MD, applied sciences—AS, non-science—NS) and applied the same predictors he found no differences among group means on father's occupational level, the home scale, or being an only child, among other predictors. There were three predictors making important contributions to the two discriminant functions. Having a father in science or technology was an important predictor for entering science either in graduate school or beginning work in the applied sciences. The second predictor was religion with being Jewish negatively related to the sciences, and the third was placement in the family, with the oldest child being more likely to enter the nonscience category.

We have already reviewed Roe's work with scientists and her theoretical structure that reflects her findings about home climates of scientists during childhood. Eiduson (1962) also used a clinical approach to the study of scientists. Interviewing 40 eminent scientists she concluded among other things that most scientists experienced periods of isolation as children, had reduced interest in children's games and activities, had no or poor relationships with fathers, frequently identified the mother with achievement and intellectual quality, and usually turned away from their families during adolescence or at college. Brandwein (1955) found that gifted science students, when compared to an equal number of matched cohorts, had parents with professional ambitions for the child while the nonscience oriented student's parents wanted financial success for their child. Visher (1947) concluded that family and community influences were important factors in the backgrounds of his 2,607 eminent scientists. And Carlson (1968) hypothesized that the following features of a child's home environment are important in the development of a science interest:

1. Achievement press

2. Warmth and democracy in the home

3. Emphasis on language development

4. Family activities outdoors, books, and science-related games

5. Firm structure of relationships and routine in the home

It is hard to disagree with the hypothesis, but many psychologists would endorse the elements as desirable for all children.

When Davis (1964a, 1965) and Fichter (no date) asked their 1964 college graduates to indicate the single most important influence on their career choice, the typical response was that they liked the kind of work they were doing. A response of particular people was more likely for the black graduates, regardless of sex, than graduates of white colleges. A number of other studies (Galinsky, 1962; Nachmann, 1960) have used an analytical framework in studying parent-child relationships and their influence on vocational development, but none have demonstrated any clear, definitive relationship between field of career choice and home climate.

A related area of study is the inheritability of work in a career field. We have already reviewed several studies (Cooley, 1963a) which have demonstrated that a choice of a career in science is related to having a father in a scientific or technical occupation. Most of the studies like Jenson and Kirchner (1955); Krippner (1963a); Mowsesian, Heath, and Rothney (1966); and Samson and Stefflre (1952) are concerned with the offspring's vocational choice. In general, we see that there is some tendency to move away from father's occupational level as a student goes through high school, but that by and large the levels are stable and identical. However, this kind of finding does not tell us precisely how inheritable a job in science is for students.

We identified only one study of the inheritability of vocations when SES was held constant. Werts (1968) used ACE data on 76,015 males who entered a 4-year college or university in the fall of 1961. He reported that 18.34% of those whose fathers were teachers said they would probably enter teaching. Engineering fathers had 24.82% of their sons indicate engineering as a future occupation, while 41.05% of the sons of physicians said they would follow their fathers' paths. Because of small Ns he had to revert to his over-chosen and under-chosen determination based on expected responses (a ratio—the product of the total number of sons in a given father's occupation times the total number of students with that choice all divided by the total sample size). Using the test he concluded that (p. 51) ". . . fathers' occupations in the physical science: chemists' sons over-chose mathematician and physicist; biologists' sons over-chose architect; scientists' sons over-chose mathematician, physicist, and biologist; and physicists' sons over-chose mathematician." None of the sons of medical men or men in social sciences over-chose a science field. Thus, as in his earlier work (1966b) Werts again concludes there is some evidence to support the notion that in the sciences as well as other occupations the inheritability of the occupation may play a role in the vocational development of offspring independent of SES.

Observations about the inheritability of vocations and related phenomena have given rise to a number of hypotheses about the cause. The most popular kind of investigation has been that related to parent-child identification patterns first posited by Bordin (1943). A number of investigators have studied the influence of parents on the interest patterns of their sons and daughters as measured by inventories. Henderson (1958), Steimel (1960), L. H. Stewart (1959), and White (1959) were some of the earlier investigators who found some relationship between interest patterns and perceived similarity between parent and self on values and attitudes. Crites (1962) investigated the relationship between identification with parent and interest patterns as measured by the Semantic Differential and Strong Vocational Interest Blank profiles of 350 students. He found that sons who identify closely with fathers have dominant interests in business-detail occupations while those who slightly identify tend to develop primary interests in the verbal-linguistic field. Those with interests in the biological and physical science areas had only average identification with their fathers. Whether or not the student had a higher identification with the opposite-sex parent had no observable relationship to a high interest in biological or physical sciences.

Steimel and Suziedelis (1963) reported the results of a study of the perceived parental influences and inventoried interests, reporting more information by field. The hypothesis they were investigating was (p. 289): "... the predominance of perceived influence by one parent over that of the other significantly affects interest as measured by the Strong Vocational Interest Blank (SVIB)." Classes of freshmen and sophomore ROTC cadets at a Catholic university were given the SVIB and a 20-item mother-father comparison questionnaire. The latter instrument measured perceived source of influence (sample questions—my mother understands me better than my father, I am more like my father than my mother). The subjects were divided into two groups on the basis of the dominance of mother or father. The analysis was based on extreme groups, since patterns of responses to the questionnaire had to widely differentiate between source of influence before the respondent was included. Akin to Crites' findings, there were no significant differences in the mean interest scale scores for biological sciences between father dominance and mother dominance groups. The same was true for mean mathematics and physics scale interest scores. However, those students with high father dominance had significantly higher mean scale scores in engineering and chemistry. However, the differences were not as great as some in social welfare and business-detail areas which were in the same direction. Since there is evidence that source of influence differs according to social class, it is unfortunate that neither Crites or Steimel and Suziedelis controlled for SES.

Hollender (1972) as well as Heilbrun (1969), followed L. H. Stewart's (1959) attempt to study the relationship between relative influence on patterns of interests and identification. Hollender concluded that maternal influence appears more important in high school while paternal influence seems to dominate during the college years. Whether this holds for science interests is not known.

There seems sufficient evidence to conclude that parental influence on vocational development, and on vocational development of scientists in particular, is of importance particularly in lower SES students. However, the nature and extent of that influence has yet to be fully determined.

Peer Groups

We have already discussed three studies of the importance of peer group processes on the adolescent's level of aspiration (Herriott, 1963; Simpson, 1962; Smith, 1963). Developmental research on reference group processes (J. S. Coleman, 1963; Sebald, 1968) generally has concluded that offspring move away from a primary reference group of family to that of peers. Here we wish to examine the effect of peer group influences on the development of an orientation toward scientific occupations.

As might be expected, most studies of peer group influences have been conducted with teenage subjects, using level of aspiration as the dependent variable. There is still some disagreement over the relative influence of peer groups on the occupational and educational aspirations of cohorts (see Haller & Butterworth, 1960; McDill & Coleman, 1965; Thistlethwaite, 1966; in addition to those cited earlier). Rehberg and Westby (1967) concluded that social class, parental influences, and peer influences all play an independent role in determining these aspirations; and Kandel and Lesser (1969) suggest that while peer influence probably is dominant in some areas of adolescent personal development, parental influences dominate educational aspirations.

Only two studies were found which dealt specifically with the effect of peer influence on science as a career choice. One, cited earlier by Dole and Sherman (1964) examined factors related to the choice of a high school science curriculum in Hawaii. They asked their 1,009 9th graders who planned to enter the college-preparatory science curriculum in the 10th grade (p. 100), "What sorts of things have you done and whom do you know that made you decide what study program you want in high school?" They compared the frequency of their science students' various responses to those of 3,768 students in all 9th grades. The science students more often cited parents (42% compared to 36%), aptitude and interest tests (35% compared to 22%), hobbies (30% compared to 24%), teachers (24% compared to 17%) and counselors (11% compared to 7%). They less often reported work experience (18% compared to 22%). There were no statistically significant differences between the groups on frequency of response to friends, teachers, people in field, free-time activities, relatives, movies and television, career day program, and random choice. The fact that nonscience students attributed significantly more influence only to work experience raises some interesting questions about the differences in perceptions or susceptibility to influence of science-oriented high school students. On the other hand, social class or dominance of college preparatory programs in high schools may be responsible for the large number of sources of influence.

From his much-discussed early study data, Davis (1964b) drew a subsample of 1,361 June 1961 college graduates in order to compare the impact of reference groups on the choice of science, to the impact of reference groups on 3,469 cases indicating some other or no preference in career choice. The dependent variable was the graduating senior's choice of science as a long-term career. In determining the effects of reference groups, Davis controlled entering career preference, quality of institution (mean National Merit Scholarship Test scores for entering classes), and college GPA. The "native academic ability" measure was an indication of whether or not the student was a National Merit Scholarship holder finalist or semi-finalist. He found that within the original groups of science preference and other, expressed preference for a science career was associated with GPA but not with school quality. When analyzing the relationship of senior year career preference to his three intellectual variables of test score, quality of institution and local standing—i.e., a statement from the subject that he was academically successful by local standards, only the latter was strongly associated with the science career preference as a senior. The actual reference group in Davis' definition is less well-defined than in studies cited earlier. Nevertheless, it is clear that in making a choice of science as an occupation, a student compares his academic success with those on his own campus, and more than likely that comparison is made to a relatively small reference group.

School

High School. The school is a social institution composed of micro social systems including teachers, counselors, peer groups, and a general neighborhood social context which includes the family (see Sewell & Armer, 1966a & b). Because of the structure of education in this country one might expect different levels of education to exert different kinds of influences. Moving from the primary or elementary school through the junior and senior high school to college and graduate school exposes the student to many different stimuli.

We have already reviewed studies in which teachers were identified as important sources of influence on choosing the college preparatory science curriculum in the 10th grade (Sherman & Dole, 1964), were important influences in choosing a college major (Ellis & Lane, 1963), and influenced level of aspiration (Rehberg & Westby, 1967).

Other studies have used school subject preferences in the elementary school, finding major sex differences. Greenblatt (1962) found that boys in general showed a significant preference for science while girls preferred music. For students with higher measured intelligence subject preferences were related to preferences for the teachers of that subject.

Ross, Denenberg, and Chambers (1956) found that high school or science teachers and books were the most influential factors in the development of 24 superior secondary school students in a science apprenticeship program. The study of the autobiographies of the students led the authors to conclude that grade school and high school teachers were important in the development of interest in science.

Several years later Finkel (1961) surveyed 594 high school seniors, 56 college freshmen, 21 principals, 65 teachers, and 24 guidance counselors to determine the role of school personnel in the choice of a science career. He found principals satisfied with program offerings and more interested in keeping unqualified students out of science than guiding potential scientists. Finkel found teachers teaching science when it was not their speciality, not providing a formal lab, teaching other courses, and carrying other administrative duties. The students were more aware of the inadequacies in the science programs than were the principals, even though the students listed science together with arithmetic and reading as the three most interesting subjects. One-third had at one time been interested in science but had changed their minds during high school. The frequently cited reasons for change were difficulty of subject matter, poor science background from elementary school, and finding science less interesting than competing courses.

L. Harmon (1961) reported the results of a study of the high school backgrounds of 7,787 individuals who received doctorates in 1958 of which 6,259 were PhDs. He found that the New England and Middle Atlantic

States produced more PhDs per 1,000 high school graduates than any other region of nine he identified. The New England and Middle Atlantic States led in the production of biological scientists, and also led in all other fields (social sciences, arts and humanities, and education). Harmon also calculated the number of doctorates per 1,000 high school graduates by class size and field of specialization. In general, the larger the class the more PhDs were produced with the largest number of PhDs coming from the 800+class interval. He concluded the physical sciences were most sensitive to class size with the social sciences not far behind. The increase in number of PhDs per 1,000 graduates between the largest class size (800+) and the 600-799 interval was striking. For all fields there were 11.03 PhDs per 1,000 graduates from high schools with the 600-799 class size, while for the 800+category the ratio was 22.18 per 1,000. This was the largest increment between any two adjacent class size intervals. The only field whose doctoral production seemed unrelated to class size was education. Harmon's census data are not definitive but do suggest questions and hypotheses.

We have already reviewed Dole and Sherman's (1964) study of Hawaiian 9th-grade students where a teacher was the second most frequently named source of influence in choosing a college-preparatory science curriculum in high school. Day (1966) like Dole and Sherman found that teachers were influential in occupational choices. He surveyed 116 seniors in a rural Oregon high school asking them: (a) what occupation they were presently considering; (b) was there any one in the area who influenced them among very close friends, teacher, relative, or other; (c) had anyone outside the area influenced them; and (d) if no personal influence, how did they arrive at the decision. He categorized the expressions of occupational choice into required level of training (college, trade school, or no formal training) and found a direct positive relationship between level of training required and frequency with which a teacher was named as an influence. He also found that boys were more influenced by teachers than girls, perhaps more a reflection of sex bias by teacher than to susceptibility to influence by girls.

H. S. Astin (1967a, p. 94) set out, "To identify the characteristics of the student's secondary school that affect his expressed career choice at the time of graduation." The 650 male subjects for her study came from the Project TALENT data bank. They were originally tested in 1960, and then as seniors in 1963 had taken the Student Information Blank which included the question of senior career choice. The 36 career choices were classified into seven categories: (a) sciences, (b) engineering, (c) education-teaching, (d) professions, (e) other—no college degree required, (f) business and management, and (g) unclassified. The independent variables were school size, the high school mean score on a reading comprehension test, and the percentage of male seniors who enter college plus 26 antecedent variables ranging from high school curriculum to SES of family. Using multiple-discriminant analysis in an attempt to discriminate among the career choices of the seniors, she found that school variables entered only the fourth- and fifth-discriminant functions with high positive weights. The fourth function separated the professions from the teaching and engineering groups, with size of high school and mean high school comprehensive reading score having the greatest positive weight for predicting membership in the professions and away from teaching and engineering. The fifth function separated the science and business groups from the teaching and unclassified groups; the mean reading comprehension test score had the highest positive weight in the function. Astin's results appear to contrast sharply with Harmon's. Astin found a low positive relationship between school size and science career choice, while Harmon found what might be termed a high positive relationship. Differences in definition, sample and methodology provide plausible explanations but the varying results do raise interesting questions.

In a study of the effects of a high school science program on science interests, Durst (1970) found that when randomly assigned students were exposed to three different introductory science courses—two experimental and one control—there was no difference in science interest as measured by the Kuder Preference Record. Johnson (1969) found that of equal numbers of boys and girls entering a high school science program in Grade 9 none of the girls finished the accelerated program, leaving a suspected cultural bias effect unexplored. The same effect was documented by Morrison (1970) who concluded that the physical sciences discourage more students than they attract except for high measured ability boys; girls with high measured ability are not attracted to the sciences.

Theoretically, the high school curriculum should provide the student an opportunity to explore his interests and test his abilities in moving toward a career. Studies of the stability of career plans during high school present a gathering array of evidence to suggest this does occur. Flanagan's (1966) Project TALENT: One-Year Follow-Up Studies is one source of such evidence. The data were based on an initial statement of career choice when the students were first tested in Grade 9, 10, 11, 12, and one year after each class finished high school. Consequently, the data reflect differences in career choice over 4-, 3-, 2-, and 1-year periods. Since his follow-up response rate varied from 37% to 69%, the data were weighted to reflect the population from which he originally sampled in 1960. As might be expected, the less time between follow-up and original statement of career choice, the more likely that the two were the same for both girls and boys. For the boys the percentages of those making the same career choice from among 31 options between the 9th, 10th, 11th, and 12th grades and 1 year after college were 16.8%, 18.9%, 25.0%, and 31.4%, respectively. A similar pattern for the girls was observed: 26.1%, 28.7%, 36.4%, and 41.2%, respectively. Percentages of those making identical choices in the sciences in the 9th grade were generally lower than overall percentages, suggesting such choices are less stable. Mathematician (3%), physical scientist (10%), biological scientist

(3%), psychologist/sociologist (10%), and engineer or scientific aid (4%) were less stable choices than the overall group of 9th-grade men (16.8%). Only engineering (18%) was as stable as all the 9th-grade men's average rate. The same pattern continues for the men until the 11th grade where the proportion making a choice of physical scientist in both the 9th and 11th grade matches the overall stability rate and remains fairly close through the 12th grade. So for men engineering is about as stable as any choice, except teacher and physician, and is more stable than any other science choice. Physical science becomes pretty stable at the 11th grade, while the rest of the sciences (biological science, mathematics, social science, engineering, scientific aide) are markedly less stable than the boys' choices in general.

The most obvious difference in the data between the girls and boys is the smaller proportion of girls making a science choice. The higher overall stability rates for the girls are heavily influenced by highly stable choices of teacher, office worker, and housewife. The stability patterns for girls choosing physical scientist, biological scientist, and social scientist are not markedly different from the boys. A choice of physical scientist by girls is less stable than for boys in the 9th-grade group, but by the 12th grade their stability almost matches the boys. While the stability of choice appears to be fairly high in general, the researchers were naturally interested in reasons for apparent instability. Cooley (1966), in the same volume, examined this question, but concentrated on the role of ability and interest in changes in expressed career choice.

Others (Hilton, 1971) have studied students in different high school curriculums and their patterns of change. But none appear to have dealt with this specifically in terms of the effect of the school on vocational development: Would students develop differently had they attended a different school and if so, why?

College. Two factors account for the previous question going unanswered: (a) longitudinal studies generally do not follow students who change schools, and (b) students generally have little choice of the school they attend.

Postsecondary students' choice of paths increases considerably. The impact of a college on its students is the topic of a recent publication (Feldman & Newcomb, 1969); portions are relevant to our area of concern. The inclusion of college as an environmental stimuli extends Crites' coverage because college majors clearly are not ultimate career choices. Nevertheless, it seemed appropriate to include studies dealing with either change in or continuation of a stated vocational choice of major from freshman year, to graduation or over a shorter period.

Three types of research were identified that are related to the topic under review. The first was the census-like reports of movement from field to field during college, or between undergraduate and graduate school, or between formal education and the job (see Schwartz, 1965; Fichter, undated). The second type, like Davis' (1964a, 1965) and Cooley's (1963a), analyzed change or persistence according to response variables such as interests, personality, or ability. The third, which we will concentrate on in this section, are those like H.S. Astin's (1969) and Thistlethwaite's (1966) which use Murray's (1938) Need-Press Thema as a foundation for studying the impact of the social climate on vocational and educational development of students.

One of the earliest systematic attempts at isolating collegiate impact on the vocational development of scientists was made by Knapp and Goodrich (1952). The investigators divided their population of institutions in the U.S. into two categories of colleges and universities from which they sampled 154 and 84 institutions, respectively. From the 1921 and 1944 editions of *American Men of Science*, they determined the field of science represented, baccalaureate institution, and date of the baccalaureate degree for the 18,000 scientists in their sample. Estimates of productivity for their colleges were computed from basic data about the schools. This productivity index was a ratio of the number of men PhDs and starred nonPhDs in *American Men of Science* to the total number of male graduates from the schools for the periods under observation. These indexes were then analyzed by several characteristics of the institution. There were five classes of independent variables: (a) qualitative variables (geographical classification by region, type of administrative control, and presence or absence of social fraternities), (b) academic variables (average size of graduating class, a mortality index based on the proportion of the total number of students graduating to total numbers of students over the 11-year period, percentage of male graduates during the 11 years to total graduates, student-faculty ratio, percentage of faculty teaching science, and percentage of faculty at assistant professor and lower level), (c) financial variables (average cost of fees and tuition, minimum student cost of attendance, endowment per student, and outlay per student), (d) entrance requirements (years of high school mathematics required for admission, average years of high school science required, and average years of high school history required), and (e) faculty and student quality (percentages of PhDs on science faculties and mean test scores of entering students). They found that colleges with high productivity rates of scientists were differentiated only on the basis of geographic region, and, for a small subsample, mean entrance test scores, and absence of fraternities. Like the colleges, middle-cost institutions had the highest productivity indexes. They also reported that the far West was most productive and universities with lowest student-faculty ratio were more productive. In conclusion they attributed differences in productivity to (p. 46) "...the prevailing atmosphere of the institution and to the type of student who is attracted to it."

Holland (1957), in a direct reaction to Knapp and Goodrich, analyzed the attendance patterns of 1955 and 1956 National Merit Scholarship Program winners and holders of Certificates of Merit to empirically test the Knapp and Goodrich conclusion which they tested in their case studies, providing some subject support for the conclusion. To guide his study Holland posed three questions: are indexes of scientist production from undergraduate colleges a function of student input (a) by scholastically superior students?, (b) by upper SES levels?, and (c) are they a function of paternal vocational motivation? For his data he drew on 556 National Merit Scholarship winners and 430 Certificate of Merit winners in 1955, and a 73% sample of 4,226 (N=3,000) Certificate of Merit winners who replied to a questionnaire about college attendance and a 10% sample of 7,500 finalists in 1957. Of course this highly selective group was in the top 2% of the students participating in the testing program. To find the answer to the first question, Holland used Knapp and Goodrich's institutions and their productivity indexes. He found that high ability students were attracted to Knapp and Goodrich's highly productive institutions over low-productive institutions by a rate of 3 or 4 to 1. Using a prestige ranking of father's occupation to estimate SES, he found no differences in SES among his subjects attending highly productive versus low-productive institutions. He then analyzed the relationship between father's occupational field as a simultaneous test of science-nonscience related occupation, and assuming differences in values, attitudes, and so forth, the paternal influence on choice of college—an indirect test, but similar to those reviewed earlier. He reported that students attending highly productive institutions were more likely to have fathers in physical activity, scientific, or social service careers. In comparison, students in low-producing schools tended to have fathers in persuasive, sales, supervisory, and leadership orientations. He concluded:

> . . . differential student populations among colleges appear as a more probable explanation of differences in productivity than the special qualities of institutions. (p. 436)

and

> This oversimplified analysis suggests that teacher influence may have marked effects on scholar productivity in the early years of the history of a college, but that this influence may decrease to the point where the level and character to the student population becomes of much greater importance as the institution develops in time. (p. 436)

Further test of Holland's contention of the value of student input to Knapp and Goodrich's productivity index, Thistlethwaite (1959) found a .38 correlation between the proportion of Merit Scholarship holders on a campus and the productivity index and correlations of .71 for males and .64 for females between this scholarship proportion and Knapp and Greenbaum's (1953) productivity index developed for a larger sample of fields, giving some support to Holland's thesis. Later however, A.W. Astin (1961) claimed these correlations were spuriously high because of lack of control over subjects' original plans and level of aspiration. From his index of talent supply (proportion of National Merit Scholarship holders in the freshman class) he computed an expected PhD productivity value for the natural sciences (NS) and the arts, humanities and social sciences (AHSS). An actual productivity figure was computed as a ratio of the number of PhDs who did their undergraduate work at the school to total number of graduates from 1939-45. The productivity index was the difference between expected and observed.

He compared the means of the productivity indexes for different types of institutions, for different geographical locations, and for different affiliations of parochial colleges. Professional or technical schools led the productivity index in the physical sciences followed by men's colleges and universities, and public-coeducational universities. The least productive institutional type was women's colleges and universities. In the natural sciences the same types of schools were, out of a ranking of seven, seventh for professional or technical schools, third for men's colleges and universities, fifth for coeducational public universities, and sixth for women's colleges and universities. He did report one contradiction to Knapp and Goodrich's conclusion that universities in the Midwest and West were more productive of scientists; he found fairly small mean differences in the productivity index of New England (191), the Far West (191), Middle West (195), and the Atlantic Seaboard (196) colleges and universities even though the means were significantly different when the South (210) was added. Protestant private institutions were more productive of both NS and AHSS. The following college characteristics had a low-positive but statistically significant relationship to the productivity index: (a) coed student body, (b) numbers of volumes in the library, (c) size of freshman class, and (d) level of training offered (PhD) and type of control (public).

Thistlethwaite also used 916 Merit finalists as participant observers of faculty behaviors in an effort to characterize the climate engendered by the faculty. When A. W. Astin (1961) reanalyzed the productivity indexes, controlling for initial career plans and levels of aspiration, the productivity indexes were markedly changed. As a result the relationship between faculty press and productivity as well as the preceding results were changed. Of the nine press variables only one was related to the productivity index.

A. W. Astin's (1961) reanalysis introduces some uncertainty regarding productivity indexes. In fact, as Astin shows, the productivity index was changed upon the introduction of student plans and levels of aspiration, thereby clouding the issue. However, the needs-press variables were more likely affected than the other data cited.

In 1960 Thistlethwaite (1960) published a more intensive study on the effects of a college environment on changes in study plans of talented students. His sample was composed of 2,026 National Merit finalists from 1956 who were contacted by mail in May of 1959. The data analysis was based on returns from 469 (92% return rate) scholarship holders and 1,031 (75%) Certificate of Merit holders representing 327 institutions or about 4.6 students per institution, clearly a restricted sampling of environmental perceptions. He asked his subjects to indicate their current major as well as the one they had planned to enter as freshmen from a list of 61 fields. The fields were then collapsed into a five-fold classification scheme: natural science, biological science, social science, arts and humanities, and unclassified fields. Engineering was included in the first category. Student needs and faculty press were assessed via a questionnaire adapted from the College Characteristic Index (Stern, 1958; 1970) yielding nine faculty-press scales and nine student-need scales. Murray's (1938) theory defines "press" as environmental stimuli which differentially meet student needs, classifying it then as a developmental theory. Thistlethwaite found for men: (a) natural sciences had the highest stability rate (proportion of those indicating no change in major since beginning college) at 80.6% and had the greatest negative gain (more students lost than recruited during a three-year period); (b) the social sciences were the next most stable at 75.5%, and had the highest positive net gain (more recruits to field than defectors); (c) the arts and humanities were the third most stable (68.6%) and had the second highest positive net gain; (d) the biological sciences were fourth in stability (64.1%) and lost more than they recruited, although not as many as did natural science; and (e) the unclassified fields were last in stability (59.7%) and gained a few more than they lost.

For the women: arts and humanities were the most stable (60.0%), followed by social sciences (59%), natural sciences (60.0%), biological sciences (50. 8%), and unclassified (50.5%). The pattern of the ratio of recruits to withdrawals for each field was identical to the men with the exception that unclassified lost more than it gained. Further, women were less stable in choice overall (61.6%) compared to 75.8% for men and they were less variable from field to field. Thistlethwaite was able to report significant differences in mean faculty-press scores on eight of the nine scales and significant differences in mean student need scales on an equal number of scales. Although not specifically analyzed in the article, the thesis was that those migrating among fields are doing so in a way that produces congruence between needs and presses. He concluded that:

> college environments characterized by a lack of faculty emphasis upon student compliance are associated with increased motivation to seek advanced degrees in the natural sciences and biological sciences. (p. 228)

Positive interactions with instructors were associated with rising aspirational levels to a greater degree than were course work and self-comparisons to cohorts or negative instructor interactions or dull courses with decreasing aspiration. That is, fewer students lowered their aspirations because of course work or instructor interaction than raised their aspirations for the same reasons. Consequently, there is some evidence that instructors and courses do little to reduce aspirations at least for very bright students who persist in school, but they can positively affect them.

Thistlethwaite (1962a) then studied the effects of college press on level of aspiration which A. W. Astin (1962) reanalyzed on the basis of inaccuracies in student reports of level of aspiration and in the method of analysis used. Thistlethwaite (1962b) then responded to Astin.

In the original article, Thistlethwaite based his analysis on a random sample of 1958 National Merit finalists who in response to a questionnaire at the end of their freshmen year, listed as a major one of 15 specific fields. There was a 67% response rate biased in favor of winners (92%). Each student was asked to recall his level of aspiration at entrance (highest degree anticipated) and his current level of aspiration (LOA). Each also completed the Index of College Characteristics (ICC), a 200-item questionnaire yielding faculty press scores on the following scales: achievement, affiliation, compliance, directiveness, enthusiasm, humanism, independence, scientism, supportiveness, and vocationalism. The ICC also gave 10 scales describing orientation of the student's associates: achievement, aestheticism, aggression, breadth of interest, competition, openness to faculty influence, participation, reflectiveness, social conformity, and scientism. As he had demonstrated in his previous study, the faculty press scales discriminated among the 15 fields. Using analysis of covariance to control for initial levels of aspiration, he compared mean levels of aspiration as beginning 2nd-year students in social sciences to natural sciences for those with a strong and weak press for independence. He found no differences in mean adjusted LOA between natural science students who reported a high faculty independence press and those who reported a weak faculty independence press. In contrast the adjusted mean LOA of social science and humanities students was higher where there was a strong faculty press for independence. He later (1962b) replicated his results using another method of statistical analysis in response to Astin's (1962) criticism.

Again in 1963 A. W. Astin used a highly talented sample of 1,548 Merit finalists in 82 colleges to determine the differential impact of colleges on the production of scientists. The students were surveyed as entering freshmen and again 4 years later to determine their plans at each point in time. He used 21 input variables from the National Merit Testing Program and the first survey as control variables on initial differences among students to try to isolate college characteristics and environmental factors (Astin & Holland, 1961) on changes in student plans (specifically whether or not they plan to do scientific research or teach sciences at a college or university).

Using multiple-regression techniques (point biserial and partial) he found small but significant effects on the criterion from type of institution variables, and environmental factors (ranging from .113 to -.181) which Feldman (1970) was to call underestimates of the relationships. Even so, correlation coefficients were very low, leading him to conclude:

> . . . the characteristics of the student of higher aptitude as he enters college appear to be much more important than college he attends in determining his final choice of career. (p. 337)

In a subsequent study, Astin (1963a) analyzed differential productivity in terms of college effect on level of aspiration. He computed probabilities of college seniors' selecting scientific research or college science teacher from eight student input variables of initial LOA, sex, career choice as freshman, satisfaction with choice, major field, scholarship held or not, verbal test score, and father's level of occupation—not all of which were used for each career choice within LOA. The probability of stating science as a career was determined as the proportion of freshmen making that statement according to the eight, or some of the eight input variables. The probability then was considered an expected value, and to determine the effects of the college he compared actual statements as seniors to the expectancies. The changes in level of aspiration were then related to five institutional characteristics and his six environmental factors and student scores on the California Psychological Inventory and the Inventory of Beliefs. He found that of the college characteristics only size, percentage of male students, and a conventional orientation (presence of business school, students interests in business fields, etc.) had significant negative influence on aspiration while the presence of a social orientation had a nonmonotonic relationship to aspiration. He also used his expected versus actual index to rank different kinds of institutions on their effects on aspiration. Seniors from coeducational liberal arts colleges expressed a significantly lower level of aspiration than was expected; the opposite was found for Northeastern men's colleges and technical institutions. So the effect of college on level of aspiration is a function of the size of school (the larger the school the greater the depression of LOA), the percentage of male students (the greater the ratio of male to female, the greater the depression of LOA), and the presence of a business school.

Davis (1964b) also studied the impact of reference group processes on the choice of careers in science focusing on the role of the faculty as a reference group. We have already reviewed his observations about the role of peers in this process (see peer group section). Among his 1,361 subjects he found student-reported faculty encouragement to be related to the choice of science; it was in fact, a more important influence than quality of institution, original career choice as a freshman, ability, or peers in choosing a career in science as a graduating senior and of greater importance in choosing advanced study in other fields. Davis concluded:

> . . . [among] students with a given level of academic ability, the better the school they attend, the less likely they are to enter scientific careers despite the fact that academic ability is one of the major variables influencing choice of science. That is the better the school a young person attends, the lower his grades are likely to be; the lower his grades, the less is his chance of being encouraged by his science teachers; and the less encouragement he received, the less likely he is to enter science. (p. 8)

For example, 66% of those students choosing science as freshmen who had graduated from a high quality institution with a GPA of B+ or better received high encouragement from the faculty as opposed to 77% of comparable students from low-quality institutions. For students choosing science as freshmen with less than a B+ average 38% of those from high quality institutions received encouragement while 50% of comparable students from low-quality institutions did. Davis' data tend somewhat to repute Holland's contention that the impact of the faculty is not as important as student input in science productivity. These raise the question of the independent contribution of faculty encouragement to pursuing science as a career.

Davis' study was followed by the 1966 study by Thistlethwaite (1966) which used discrepancy scores between expected and observed levels of aspiration as seniors for 1,772 National Merit finalists responding to three sequential surveys at 140 colleges to investigate the effects of teachers and peers on student aspirations. As the author points out, the unreliable nature of discrepancy scores and biases in the sample preclude generalization to populations as a whole, but he did find that (p. 44) students' disposition to seek advanced training is strengthened by association with peers having high educational aspirations, teachers giving favorable evaluations, undergraduate research experience, participation in honors programs, and winning social recognition for academic achievement.

After his National Merit studies, Astin began a study of the educational and vocational development of a broad range of college students.

In their major report of the culmination of four years of data gathering and analysis, A. W. Astin and Panos (1969) present the single most comprehensive longitudinal study of college students. Their 1969 report makes it explicit that productivity is a misnomer; that, in fact, the productivity indexes are actually measures of educational and vocational development of students in colleges with different characteristics and environments.

Analysis of the impact of colleges began in 1961 when 246 accredited 4-year colleges and universities administered the American Council on Education questionnaire to 127,212 entering students. The questionnaire asked for 52 different pieces of information scored dichotomously to produce a total of 84 input measures. The measures included descriptions of the entering classes of the 246 institutions using such items as percentage of men in the entering class, percentage of students who were president of their high school class, and percentage planning to become scientists and obtain their PhD. It will be recalled that similar kinds of input measures were used in Astin's earlier studies to estimate expected outcomes of college. Factor analysis reduced the input measures to six factors: (a) intellectualism (academic ability, high educational aspirations, interest in science), (b) aestheticism (interest and ability in art, music, and writing), (c) status (socioeconomic level of students, interest in enterprising careers), (d) leadership (past high school accomplishments out of class, drama, and speech), (e) pragmaticism (high interest in engineering and technical fields, coupled with low interest in education and social science), and (f) masculinity (high percentage of men, large percentage expressing interest in professional careers with low interest in education and social science).

The student output data were obtained in the summer of 1965 from a follow-up survey of 60,505 student subsample of the original sample. The follow-up again asked the students about their probable future vocation, final major, and highest degree planned to provide a pre- and post-treatment measure of development. About 68% or 36,405 of the students responded to the follow-up questionnaire. Twenty-five other output measures were obtained in the follow-up questionnaire including such things as GRE Area tests, graduation within 4 years of starting, and intention to enter graduate school. Two kinds of college data were gathered. One was called "between college" and the other "within college" and, as their names imply, referred to stimuli to which all students at a particular college are exposed (characteristics of school) and stimuli within a particular college to which respective students may be differentially exposed (e.g., living in dormitory, participating in an honors program).

The between-college measures came from the Inventory of College Activities (ICA) which when subjected to factor analysis yielded 27 dimensions (pp. 10-11):

A. The Peer Environment
    1. Competitiveness-cooperativeness
    2. Organized dating
    3. Independence
    4. Cohesiveness
    5. Informal dating
    6. Femininity
    7. Drinking versus religiousness
    8. Musical and artistic activity
    9. Leisure time
    10. Career indecision
    11. Regularity of sleeping habits
    12. Use of library
    13. Conflict with regulations

   14. Student employment
   15. Use of automobiles

B. The Classroom Environment
   16. Involvement in the class
   17. Verbal aggressiveness
   18. Extraversion of instructor
   19. Familiarity with the instructor
   20. Organization in the classroom

C. The Administrative Environment
   21. Severity of grading
   22. Severity of administrative policy against drinking
   23. Severity of administrative policy against heterosexual activity
   24. Severity of administrative policy against aggression
   25. Severity of administrative policy against cheating

D. The Physical Environment
   26. Spread of the campus
   27. Friendliness of dorm counselor or housemother
   28. Role of cheating (an additional factor used sparingly in the analysis)

The 27 ICA stimulus factors plus eight image factors were used to describe the environmental differences among the colleges. The image factors were student perceptions of the environment:

1. Academic competitiveness
2. Concern for the individual student
3. School spirit
4. Permissiveness
5. Snobbishness
6. Emphasis on athletics
7. Flexibility of the curriculum
8. Emphasis on social life

A number of other measures of college characteristics were also used in the analysis including size, per student operational expenditures, percentage of men in the student body, and the college's degree of selectivity. Each college was classified by the Environment Assessment Technique (EAT), essentially the relative curricular emphasis on different subjects. The EAT categories correspond to Holland's (1966) classification of occupations:

1. Realistic orientation (engineering and agriculture)
2. Scientific orientation (natural science and mathematics)
3. Social orientation (education, nursing, and social sciences)
4. Conventional (accounting, secretarial, and business)

5. Enterprising orientation (prelaw, political science, history, and business administration)
6. Artistic orientation (fine arts, music, writing, languages, and speech)

Also used as between-college measures were six other "type" kinds of data about the colleges including type of control, function (teachers college, liberal arts college, university, technological institution), sex, race, geographical region, and size of town housing the institution.

Thirteen dichotomous measures of within-college variables tapped things like source of financial support (parents, scholarship, loan, work), residence at college (parents, dormitory, private arrangements, fraternity or sorority), use of personnel services (four or more, 10 or more hours of vocational counseling), marriage, and participation in the undergraduate Research Program of the National Science Foundation.

Using the 84 input variables in stepwise multiple regression procedures to predict each of the 28 output variables on a subsample of 3,821 students, Astin and Panos established expected outputs or changes in educational and vocational plans and activities. These expected outputs were then subtracted from the observed changes in each student's plan and activities to yield a "residual" output. The object was to determine the relationship between the college treatment variables—the between and within college measures—and the residual scores. We will concentrate on their investigation of the determinants of career choice and field of study.

The following figure contains: (a) popularity of a choice in 1961 (in parentheses above the choice), (b) the stability rate, and (c) the relative change from 1961 (pp. 86-87).

	Percentage Stability-Identical Choice in 1965 as in 1961	**Relative Percentage Change Between 1961 and 1965**
(5) Engineer	36.1	-41
(11) College Professor	25.3	+416
(6) Chemist	20.0	-42
(1) Physicist	18.1	-54
(2) Biological Scientist	14.1	-20
(4) Psychologist	10.7	+11
(1) Mathematician	9.2	-42

The relative percentage change was based on 1961 choices of the career and takes recruits and defectors into account. In discussing another presentation, Astin and Panos state the conclusions best:

> College professor, housewife, and businessman were the careers manifesting the largest net gains overtime . . . the largest net losses occurred in the three categories that are most closely allied with science and mathematics: physician or dentist, engineer, and natural scientist. Indeed, if undecided and nonresponding students are excluded, all career choices which registered net losses during the undergraduate years were science related. (p. 89)

In comparing their observed rates of stability to those found by Davis (1965), Astin and Panos (1969) concluded the relative ranking on holding power is the same, but that rates differ—they found a lower stability pattern due to a variety of factors, including Davis' reliance on recall of his subjects' entry career choices and differences in the occupational classification scheme. One source of confusion came from Astin and Panos' (1969) category, college professor, which was apparently heavily weighted with educational specialists.

In studying the influences of within-college effects on residual career choice and major field scores, Astin and Panos based their analysis on 1,590 students for whom they had National Merit Scholarship Test scores since differences in ability or achievement levels at entrance among students had not been adequately controlled in previous analyses when high school grades were used as covariates. In this analysis they found small but significant, and in some cases unexpected, results. For example, they found (p. 110) that the student who lived at home, in a fraternity house, or in a dormitory during his freshmen year appeared less likely than other students to pursue a career as a school teacher (-.05; $p<.05$). In an era when freshman women were required to live in dormitories and education dominated as a career goal, the results were unexpected. Others confirmed logical analysis, (e.g., early marriage was negatively related to pursuing an advanced health degree). Receiving money from parents for education was related to pursuing an advanced health degree and was less likely to result in a business major or in a career as a businessman. Otherwise within-institutional stimuli were not systematically related to career choice or major residuals.

Between-college measures accounted for more of the residual variance in the engineering career choice than for any other field (69.7% for all 72 college variables), with lawyers following at 46.5%, teachers at 36.5%, and college professors at 28.1%. In the remaining sciences, residual variance accounted for from 18.1% to 27%. In general, except for engineering, students' perceptions of the press of the college or stimuli were more related to the residual career choice and major field scores than were the "type" variables. Engineers were so much more likely to come from technical institutions than any other kind that the type of school variable overpowered all other variables. The residual choice of scientist or engineer was more subject to influence by the EAT measures than any other residual career choice. The EAT measures were constructed to reflect relative emphasis of curriculum program in six areas and because of the tendency of engineers to be highly stable in technological institutions, their openness to other curriculum changes is expected. In effect the conclusion might be that engineers and scientists experience more change than confirmation in vocational development. The distinction between confirmation and change as indicators of vocational development is not unlike exploration and crystallization and other theoretical concepts.

Overall the Inventory of Student Characteristics accounted for more residual variance on career choice than did the EAT measures. It seems plausible that the reasons for the general lack of importance of EAT variables is that true characteristics of institutions may not be as important as student perceptions of the characteristics in influencing vocational development.

To systematically observe the relationship between residual career choices and EAT, type and ICA factors, Astin and Panos used multiple-regression procedures. For biological sciences the residual was most associated with the lack of unorganized dating on campus (-.18), the presence of competition in the classroom (-.23), and the location of the school in a small town (.15). Again, engineer's residuals were highly related (zero order r of .78) from being at a technical institution, a low social curriculum orientation on campus (-.31), and low emphasis on enterprising curriculum (-.37)—the latter two would be absent on technological campus. The physical scientist's residual choice was also positively related to coming from a technical institution (.24), with a low proportion of men on campus (.23) and the presence of informal dating (.16). The social scientist's residuals were related to coming from a predominately Negro college (.15), presence of informal dating (.15), career indecision (.18), and a private nonsectarian institution (.20).

What does this all mean? First, even if part correlations under-estimate the real relationship (see Feldman, 1970) between the residual scores and college characteristics, the deficiency would have to be about 10 times below the real correlation to account for a sizable amount of variance. The basic assumption in their methodology is that when viewing college student development in the future, we now have some *a priori* considerations which if applied to the establishment of the residuals for other students, the residuals would disappear. Unfortunately, this has not been attempted as far as we could tell. If it had and if stepwise-multiple regression procedures were applied, it appears likely, because of the magnitude of the part correlations, that the addition of variables would have ceased before the college characteristics entered the function with significant additions to the amount of variance accounted for. Moreover, the procedures used in the study do not really reveal information about the nature of the growth. Nevertheless, establishing that some student development occurs which was not accounted for strictly by student input variables is important and makes a valuable contribution to the field of vocational development.

H. S. Astin (1970) used Project TALENT data on 7,022 students in an investigation of the personal and environmental variables affecting the vocational development of young women. The environmental variables included experiences in high school, educational status, marital status, number of children, and so on in an effort to discriminate among women expressing one of nine career choices five years after they left high school. Using discriminant analysis with 13 predictor variables she found three functions which accounted for 66% of the variance. The first discriminant function discriminated between science as a career choice and the more typical choices of housewife and office work. The second function discriminated among professions, business, office work, and housewife. The third discriminated between the sciences and the health and arts fields. As might be predicted, college attendance, advanced training, and being single were related to expressions of career choice in science.

Chapter III

RESPONSE VARIABLES

Response variables include general academic ability, aptitudes, academic achievement, interests, personality, and of course, vocational choice. The role of response variables is more difficult to visualize and define than was the role of environmental stimuli in the process of career development. The environment represents constraint, opportunity, and reality which all act on the individual. The individual then responds or reacts to these stimuli in terms of his individual characteristics.

The origins of response variables have been attributed to both heredity and environment as well as their interaction. In the first view environment plays a fairly passive role in response magnitude and frequency while from the others environment shapes response variables. This section includes studies that focus on the relationships among various responses to the specific response of vocational development.

Cognitive Development

It is customary to classify the dimensions of the cognitive domain into intelligence and aptitude and the tests of cognition into intelligence, aptitude, and proficiency (Anastasi, 1968; Cronbach, 1960; Super & Crites, 1962). The distinctions come from factor analytic research on the structure of the intellect by Guilford (1959), Spearman (1927), and Thurstone (1924) which has identified as many as 40 factors in this structure. In general, research on impact of cognitive development on vocational development has concentrated on Spearman's "g" or general intellective power and a relatively small number of traits, tending to ignore factors such as intellect, contents, and products which Guilford proposes as interactive.

An overwhelming portion of the research on the intellect as its relates to vocational development is concerned with predicting educational success. However, failure in a training program is not synonymous with failure in vocational development, although it may be symbolic of process deficiencies including deficiencies in the training or educational program. Failures as well as successes are an inherent part of vocational development. Thus we have concentrated on studies dealing with vocational choice or equivalent expressions because they subsume the issue of success and failure. We have chosen not to include the literature on scientific creativity (Taylor & Barron, 1963) because in our judgment it has a thrust of differentiating between successful and unsuccessful scientists. The remaining literature appropriate for the review is divided into three topics: general academic ability, achievement in and out of school, and aptitudes.

Intelligence or General Academic Ability

The classification of particular studies by their criteria and instrumentation as either general ability, proficiency, or aptitude tests is fairly arbitrary. Aside from some individual tests (Cronbach, 1970), most of the group tests of general ability yield estimates of one or two general abilities or in some cases, a number of scores on a test will be summed and averaged to give the one or two scores. Spearman's "g" (1927) then is seen as the general level of intellective power which is composed of a number of intellective traits. In general those instruments which give only one score are not used with groups, certainly to the degree they were a decade or more ago.

In his study of the development of future scientists, Cooley (1963a) used several indexes of scholastic ability at each of his overlapping steps: (a) 5th to 9th grade, (b) 8th to 12th grade, and (c) 11th to the 3rd year after school. His approach was to determine the predictability of vocational development toward the sciences or in some other direction using a longitudinal, overlapping design. To determine the role of aptitudes, achievement, and general ability during the period from the 5th to the 9th grade, he classified his boys on the basis of their 9th-grade plans in one of three groups: (a) plan a career in science (PSP), (b) plan college but not science (CNS), and (c) plan no college but technical work (NCT). The Sequential Tests of Educational Progress (STEP) (1957) Science, STEP Math, STEP Reading, and Otis (1937) tests were used as indicators of scholastic ability and predictors of plans. Although the PSP boys had higher average scores on all but one of the tests than the other two groups, the prediction was not very powerful. The Otis, a general ability test, added little to the predictability of plans, leading Cooley to the conclusion that between the 5th and 9th grades, general ability, aptitudes, and achievement indexes are only slightly related to level of career plans.

The role of general ability levels in vocational choice during the collegiate years has been the object of two kinds of research. The first are attrition studies like that of Reid, Johnson, Entwisle, and Angers (1962) who found that students leaving engineering during the four college years have poorer high school achievement records, lower Scholastic Aptitude Test Quantitative scores, and lower School and College Achievement algebra scores than do those that persist. The second kind of study investigates the hypothesis that students with similar goals look like each other but look different from students with other goals (Cole, Wilson, & Tiedeman, 1964).

Another example of the second type is Elton's (1967) study of male entrants to the University of Kentucky. He examined the relationship of general ability as measured by the American College Testing Programs (ACT) Composite test score and personality traits as measured by the Omnibus Personality Inventory to career choice and career role. The indication of career choice came from the ACT test battery which the student completed before he enrolled; ACT used eight classes of occupations (Administrative-political-persuasive, Scientific, Engineering-agriculture-technical, Medical, Arts-humanities, Business-finance, Not listed, and Don't know) which Elton used as criterion groups. The discriminant analysis yielded two functions. The first was a science-business continuum separating the engineering-agriculture-technical and scientific groups from the administrative-political-persuasive group. The ACT score was only moderately related to being at the science end of the dimension. In the second function, the ACT score had the highest weight in separating the business-finance group from the arts-humanities group. These results suggest that a high level of general ability is less related to vocational development toward the sciences than are personality traits. However, Elton also considered a career dimension only occasionally studied in connection with scientific career choice. Also as part of the ACT battery subjects had indicated the role they expected to play in their occupation: (a) researcher, (b) teacher-therapist, (c) administrator, (d) promoter-salesman, (e) practitioner-performer-producer, (f) not listed, and (g) don't know. In the second discriminant analysis he observed a science-scholarly interest continuum as the first function separating the researcher-investigator from the promoter-salesman group. The general ability level of the student carried the greatest weight together with scholarly orientation in predicting membership along the dimension, with those in the researcher-investigator category having the highest ability levels and greatest scholarly orientation.

The ACT Composite score is actually an average of four scores; three are highly verbal. Elton's results suggest that when such a highly verbal, single score is used to estimate ability levels and when the role in the occupation is defined, both ability level and personality traits delineate the development toward science.

The same kind of science-scholarly dimension has been observed by others (Cooley & Lohnes, 1968; Williams, 1968) when role in the occupation and general ability are measured in a different way; this dimension disappears when the criterion is changed to combine role, field, and level of choice (Elton & Rose, 1970). A problem in such studies is the probability that high school or pre-high school subjects may hold inaccurate or inadequate role stereotypes for the sciences. For example, the role of researchers in the social sciences or humanities may be virtually unknown. Consequently, when asking younger subjects for a vocational choice, dimensions of role, level, and direction are appropriate only if the subject is able to distinguish among them.

In the Project TALENT One-Year Follow-up studies (Flanagan & Cooley, 1966) general ability as measured by the English total and mathematics total scores was related to expressing an interest in a science-related career, but the dimension was one of level in separating the college bound from the noncollege bound. In their subsequent report, Cooley and Lohnes (1968) observed a "science-oriented scholasticism" dimension as the primary function when occupational role was made a part of the vocational choice criterion groups.

The work of Cooley and Lohnes is one of the best examples of the role of general ability level in the prediction of vocational development. Their report was based on the Project TALENT Grade 12 sample that had been followed for 5 years. They classified the 12th-grade and 5-year follow-up career plans of 4,217 boys into 10 groups: (a) PhD or MD in the biological sciences; (b) DDS, MS, or BS in the biological sciences; (c) PhD in physical sciences and mathematics; (d) MS or BS in physical sciences and engineering; (e) skilled and technical with training; (f) laborers, no post-high school training; (g) clerks and office workers, no post-high school training; (h) noncollege, nontechnical, with post-high school training; (i) BS or BA, sociocultural; and (j) graduate school, sociocultural. Three separate discriminant analyses were performed using the 22 factors Lohnes (1966a) identified in the TALENT battery. One analysis was conducted using 12th-grade plans as the criterion, another using 5-year follow-up plans as the criterion, and the third was based on changes in plans between the 12th grade and the 5-year follow-up. In each analysis three functions were found, and in each case their utility was highly similar. The first was called a "science-oriented scholasticism," the second "technical versus sociocultural," and the third "business versus cultural." The first separated the careers requiring college and advanced degrees from careers not requiring post-high school training, thus describing essentially a level dimension. The second located the scientific and career plans at one end of the dimension with the sociocultural plans at the other, while the third separated the business from the sociocultural. In the first two functions, the index of general ability was related to being in a scientific or technical career path. However, mathematics achievement, scholastic interest level, visual reasoning, outdoors-shop, and sociability had more influence on placement than did general ability level. Thus, the relative role of general ability in movement toward a science or technical career is defined differently according to the empirical nature of the investigation. In Cooley and Lohnes' work the general ability index is only moderately related to the other achievement and aptitude indexes which play a more important part in the prediction. A high level of general ability then, is related to movement toward the sciences or toward technological occupations, but it is not a sufficient condition and perhaps is not the most important condition.

The same kind of conclusion can be reached from Elton and Rose's (1970) study of the vocational development of college men. Although their major purpose was to test Holland's (1966) theory of vocational choice, their results are relevant here. In their discriminant analysis the independent variables were personality traits measured by the Omnibus Personality Inventory, general ability level indicated by the ACT Composite test scores, and freshman career choice categorized by Holland's six types: (1) Realistic, (2) Intellectual, (3) Artistic, (4) Social, (5) Enterprising, (6) Conventional, plus Undecided. Like Cooley and Lohnes, they studied the predictability of career choice by looking first at the choices of all 530 seniors then at the 299 persisters—those whose freshman and senior choices were in the same Holland category, and finally at the 231 unimigrants or persons whose career choices changed between the freshman and senior year. Holland's Intellectual category is composed of science occupations but does not include engineering and behaves much like a science grouping used in other studies. For example, in this study there was a net out-migration from the category between the freshman year (N=221) and the senior year (N=137). Overall, the conclusions were (p. 5), "The efficiency of predicting occupational choices over a 4-year period by personality and ability variables is not impressive compared to that found when only freshman-expressed choice is used to predict senior occupational choice." While the prediction of development was unimpressive, those subjects in each senior year criterion group differed from members in other groups on ability and personality measures. In this connection, they examined the differences among and within the senior year criterion groups on the personality and ability measures by first looking at all seniors, then at just the persisters, and finally at the changers. In each case the primary function separated the Intellectual groups from the Enterprising groups and ability level carried the greatest discriminant weight. As in the studies by Cooley (1966a, b) and Cooley and Lohnes (1968) ability was the most important predictor of change. So the Intellectual occupational choices were made by those with high general ability although there were greater differences among the groups on two personality traits of the members than on general ability. Elton and Rose, then, found that a common science orientation is a primary dimension on which career choices can be distributed, but that it does not have the clear level connotation that the previously reviewed studies found. The differences probably can be attributed to the exclusion of noncollege students and the criterion classification scheme.

In a study that concentrated on high ability students, Watley (1969b) found that the College Entrance Examination Board Scholastic Ability Test was not related to rate of progress toward advanced degrees although personality traits were.

Following N. Stewart's (1947) study of occupational categories with its reliance on enlisted servicemen, Wolfle provided a new dimension. Wolfle and Oxtoby (1952) published the results of the Commission on Human Resources and Advanced Training's work on ability levels of students in different specialized fields. The basic test was the Army General Classification Test (AGCT), a general ability test with a mean of 100 and a standard deviation of 20. The undergraduate data came from approximately 10,000 new graduates of 40 colleges and universities. The graduate student data were supplied by the University of Washington, the University of Pittsburgh, and 40 other schools to form a sample of 4,500 graduate students. Data about the PhDs came from Ohio and Minnesota colleges and included 1,100 PhDs. The average BA holder had an AGCT of 126, considerably higher than the total population mean (10% of the population scored this high). The average graduate student's score was 129 and the average PhD in the sciences scored 138. All college graduates scored higher than the population mean; the authors point out that the difference between the mean score in the highest field, physics, and the mean of the lowest, physical education, is less than the difference between physical education and the population mean. Despite consistent differences, the overlap among fields at all levels was dramatic. Regardless of the age of the subject or his age at testing, those in the physical sciences were always highest in mean score followed by those in chemistry and engineering. Biological sciences were always near the mean, as were the social sciences.

Like N. Stewart (1947), Wolfle and Oxtoby (1952) and Wolfle (1954), Thorndike and Hagen (1959) used military test data to look at differences among those in different occupations. Unlike Stewart but like Wolfle, their sample was lacking at the lower levels of the occupational structure. Like Wolfle, they concluded that while they were able to discriminate among the occupations of the 10,000 former Air Force Flight Cadets on a variety of military aptitude and achievement tests, the discrimination was not particularly powerful. In fact (p. 321) they concluded there was greater variance within jobs than among them in terms of aptitudes and abilities. Cooley and Lohnes (1968) in reviewing the results concluded that the fault lay in their occupational classification schema and not their methodology.

In summary, we cite Super and Bohn (1970) who examined the topic of cognitive measures in differentiating among occupations:

> On measures of intelligence, there is a definite hierarchy among occupations, but most occupations have distributions similar to an overall average. Within each occupation there is considerable variation, ranging from the very able to the less able. By the same token, there is considerable overlap among occupations on levels of intelligence (p. 80).

Achievement Patterns

Since achievement in school is related to general ability level and even more highly related to standardized tests of achievement, it would follow that school achievement patterns would be useful in predicting the level of vocational choice. Further, it might be hypothesized that future scientists and technologists exhibit higher achievement in science-related areas than do other students. From what we know about future scientists' high level of general ability, they would not be expected to excel in all areas of achievement, particularly in the early school and high school years.

Between Grades 5 and 9, achievement, like general ability, does not appear to be related to pursuing a science career path. Cooley (1963a) gave 165 5th-grade boys the Sequential Test of Educational Progress (1957) Science, Math, and Reading subtests and calculated the relationship of the results to the boys' 9th-grade career plans classified as college-science (PSP), college nonscience (CNS), or noncollege technical (NCT). The STEP Math and Science subtests were readministered at 8th grade. There were significant differences among group means on the 5th-grade math test and 8th-grade science test, but the prediction of group membership was weak. Consequently, achievement in science and math during this period was not related to direction of career choice at the 9th grade. The findings may be due to instability or immaturity of career choice at the 9th grade, an expected condition (Crites, 1971; Super & Overstreet, 1960).

In his study of the 8th- to 12th-grade period, Cooley (1963a) used measures of ability, achievement, and aptitudes as predictors of the 12th-grade career choices of 149 boys. The four criterion groups were the prospective science pool (PSP), the college nonscience group (CNS), the noncollege technical (NCT), and the noncollege nontechnical group (NCNT). Contrary to his junior high school findings, achievement, ability, and aptitudes were related to category of career choice. The two discriminant functions determined through his analysis could be called a level function and a science—nonscience function. The greatest differences among group means were in terms of general ability with a distinct level effect separating the college bound from the noncollege bound. Yet the STEP Math and Science achievement tests were more predictive of group membership in the measurement space. During the high school years those following a science path begin to excel in math and science compared to the other three groups and the NCT group performs better in math and science than does the NCNT group. The results suggest that success in science and math helps direct students toward science and technology.

The two dimensions to the measurement space that Cooley observed in 1963 were found again in the Project TALENT One-Year Follow-up Studies (Flanagan & Cooley, 1966). One objective of the study was to determine the predictability of career plans from the 9th grade to 1 year after high school (Cooley, 1966b). The sample consisted of 5,857 male students first tested as freshmen. The criterion was follow-up career plans 1 year after high school classified as college-physical science, college-biological/medical, college-nonbusiness, college-business, noncollege science/technology, or noncollege nontechnology. The correlates of vocational development were

50 variables of achievement, aptitudes, interests, personality traits, and information. The two achievement indexes used in the prediction were mathematics (arithmetic reasoning, introductory mathematics, and advanced mathematics) and English (spelling, capitalization, punctuation, usage, and expression). The knowledge traits were defined (Lohnes, 1966b, p. 79) as "an ability to recall and apply information in a subject-matter area" and were clearly related to school experiences. When looking at only those subjects who had changed career plans between 9th grade and the follow-up, abilities were more predictive of change than were interests. In predicting final group membership for all subjects, achievement played a major role in the first or level function, while aptitudes and interests, or specialized knowledges, depending on how one prefers to classify the TALENT information tests, functioned better as discriminating variables on the science-technology dimension of direction of career orientation. General knowledge served as a level discriminator, while aptitudes and specialized knowledges served as directional discriminators. The college groups were higher in achievement than the noncollege in both math and English, and the college physical science and noncollege technical groups had higher mechanical aptitudes, spatial visualization, math information, and physical science information. Despite all the testing and the fact that the nonability measures were slightly better predictors of group membership, the students' 9th-grade plans were slightly better predictors of group membership than were the ability and motive measures.

H. S. Astin (1967a, 1968) using TALENT data to study the career development of high school boys and girls, found that math achievement and English achievement were related to changes in plans and membership in science career path groups, but initial career choices and nonability measures were more predictive of group membership than were the ability measures.

This pattern of relationship between achievement and level of career choice is seen again in Cooley and Lohnes' (1968) study. Their comprehensive study of the predictability of development in young adults used a variety of ability tests and what they called motive variables (Lohnes, 1966b). The 60 ability-domain variables were redivided into 13 factors by factor analysis. The 38 motive-domain variables were reduced to 13 factors by the same procedure. The cognitive domain was broken down into three dimensions: Educational Achievements (verbal knowledge, mathematics, English language), Differential Aptitudes (visual reasoning, perceptual speed and accuracy, memory), and Specialized Knowledges (hunting-fishing, screening, color/foods, etiquette, games). The motive factors were grouped as follows: adjectival self-concepts (conformity needs, impulsion), autobiographical activities (scholasticism, activity level), inventoried interests (business, outdoor and shop, cultural, science), and the "N" and "A" scales (leadership, sociability, and introspection). In general they found the verbal knowledges, mathematics, scholasticism or academic orientation, and the four interest scales were the most powerful predictors of development. As a foundation for their work they cite William's (1967) discriminant analysis of high school curriculum groups of a sample of 3219 male and 3397 female TALENT 12th graders. He found that one discriminant function separated the curriculum areas into two general groups: the college-preparatory group and others. For both men and women the factor carrying the highest weight was scholasticism, followed by the mathematics achievement factor and the science motive and verbal knowledges factor, leading Cooley and Lohnes to name the function *science-oriented scholasticism*. In their work they used the previously defined factors in a discrimination approach to classify male college graduates, tested 5 years earlier, according to their major field at graduation. There were 24 majors identified for 4,487 subjects. The two best discriminating functions were titled technical versus sociocultural and cultural versus business and social. In the first function, the mathematics knowledge factor had the highest loading (.73), followed by science interest (.55), cultural interests (-.54), and sociability level (-.45); only math knowledge appears to be a highly functioning ability. In the second function, cultural interests (.65) and verbal knowledges (.57) had the highest positive weights. The sciences (engineering, physics, mathematics, premedicine, and dentistry) and the biological sciences were placed high on the technical end of the first function and toward the midrange on the second function. In general they concluded (p. 2-24), "On these and all the discriminant functions to be reported the abilities and motives factors work together to separate the criterion groups." Of their 2,648 subjects expressing a plan to enter graduate school, high mathematics knowledge, verbal knowledge, and academic interests coupled with low cultural and outdoor interests seemed to differentiate them from those not going on to graduate school. There is marked similarity of the two best discriminant functions using graduate school majors as criterion groups to those using undergraduate majors. Cooley and Lohnes even named the functions the same; the ranking of the weights of the factors was similar and the location of the centroids of the majors in the discriminant plan was almost identical.

Probably the most important aspect of their work, reported in their Chapter IV, was the prediction of career patterns. Using the male subjects first tested as seniors in 1960 and followed up in 1965, they studied the predictability of plans as seniors, plans after 5 years, and change in plans. As seniors the criterion was a 12-category classification of career plans which also included level of aspiration. For example, PhD or MD in the biological or medical sciences (MED); DDS, MS, or BS in the biological and medical sciences (BIO); PhD in physical sciences or mathematics (RES); and MS or BS in engineering (ENG). Using the predictors discussed earlier (MAP Profile) in a discriminant analysis they found three major contributing discriminant functions named science-oriented scholasticism (like Williams, 1967), technical versus sociocultural, and business versus cultural. The first function separated the MED, BIO, RES, and ENG groups from the socio-cultural and business groups and used math knowledge, scholasticism interests, science interests, and verbal knowledges in that order. The second function and the third relied primarily on motive factors in the separation but made use of two aptitude factors, visual reasoning and perceptual speed and accuracy.

When looking at plans at the end of 5 years, they summarized (pp. 4-68), "The similarities in the detail of the findings . . . are remarkable." They observed almost exactly the same three discriminant functions. In studying the predictability of change, they classified changes in plans between the 12th grade and 5 years out of school into 1 of 41 change groups, again computing the same three discriminant functions. They concluded that migrant groups move toward their stable targets. Of the 3,142 in the Grade 12 college science oriented group, 1,895 were so classified after 5 years. From among students classified in a nonscience group in Grade 12, 618 moved into one of the science groups at the end of 5 years. It appears then that students migrate toward groups in terms of a variety of dimensions, and the sciences become more homogeneous as a result of this migration. The question then is: if you can successfully discriminate among students with different majors at any point in their collegiate career, can you predict changers or "path jumpers?" Perhaps the best answer to date lies in Cooley and Lohnes' career tree where observed proportions of students make changes at different points in time and form basic probabilities of changing direction as well as persistence. This approach doesn't tell why the changes or why the persistence or why the decision was made, but it does provide useful data.

Continuing the review of Project TALENT 5-year data, Richards (1971a, 1971b) reported the study of predictability of career plans and choice of major, returning to an occupational model of prediction.

Since the career choices of the subjects had shown a large amount of instability between the original testing as juniors and seniors in high school and the 5-year follow-ups (Richards, 1971c), it is not surprising to find that the predictability of career choice was low. The predictor variables were 45 noncognitive variables and the criterion was membership in or not in 1 of the 37 categories of choice (more categories than Cooley & Lohnes, 1968 or Cooley, 1963a). There was not enough detail to answer the question of difference in predictive efficiency between achievement and aptitude testing. However, for those in the sciences and technology there was little difference between the use of cognitive and noncognitive variables. Engineers were most predictable (.33 point biserial) followed by college professors, physical scientists, biological scientists, and so on. The sciences seemed to be among the most predictable choices along with farmer and skilled worker. Studying the predictability of college majors Richards concluded that interest scores tended to predict choice better than cognitive variables which seemed to predict success better. In comparing his empirical predictions to student predictions of career and choice, he concluded they were equally efficient, but that tests identified recruits to fields while self-predictions typically do not.

In a previously discussed study, H.S. Astin (1970) studied the predictability of the career choices of 7,022 girls 5 years after high school from Project TALENT test data gathered during high school. She used 10 categories of careers as the criterion groups, five information or interest tests (Super & Crites, 1962), and six aptitude and achievement tests as predictors. Again we find the sciences at the extremes of four of the five primary discriminant functions. Mathematics achievement, mechanical reasoning, and creativity test scores entered the five discriminant functions but not with the weight and frequency of interest inventory, test scores, or prior vocational choices. But as Flanagan & Cooley (1966) found, those who defect from the sciences are primarily those who were less scholastically able.

Aptitudes

Not only is there agreement that a general intellectual ability factor exists, there is also agreement that it is composed of a number of specialized abilities called aptitudes. Although the specific number of aptitudes that have been identified ranges up to 40 (Guilford, 1959), most research in vocational psychology focuses on a fairly limited number (Super & Crites, 1962).

Like many tests, those concerned with aptitudes either as multiple aptitude test batteries or single aptitude indexes report norms for students in different programs or workers in different occupations (see for example, the General Aptitude Test Battery or the Differential Aptitude Tests battery references in the *Seventh Mental Measurements Yearbook,* Buros, 1972). However, scale by scale comparisons like those of Millholland and Womer (1965) should clearly be a thing of the past. Prediger (1971) has shown, as have Cooley and Lohnes (1968) and their colleagues at Project TALENT, that patterns of aptitudes are more revealing than are single scores. Moreover the technology of discriminant analysis has clearly been shown (Prediger, 1971) to be a superior methodology in studying career patterns in a developmental trait and factor approach. Therefore, only those studies using patterns of aptitudes as predictors are reviewed in this section.

Tyler (1964) found that 12th-grade interest in science was not related to achievement, aptitudes, or general ability test scores obtained from testing earlier in the school careers of her male subjects. However, Cooley (1963a) reported that male students moving toward the sciences and technology as high school seniors had different aptitude patterns than did his other subjects. The meanings of the differences were unclear, however, due to the statistical properties of the test he used to assess aptitudes.

Cooley's (1963a) Scientific Careers Study, it will be recalled, used a 5-year overlapping design and multiple discriminant analysis procedures to differentiate among four groups (Prospective Scientists Pool—PSP, College Bound Non-Scientists—CNS, Non-College Technical group—NCT, and Non-College Non-Technical group—NCNT) followed from the 11th grade to the 3rd year in college at which time their group membership was determined. One of his major discriminant analyses was based on seven indexes of aptitudes and general academic ability level. The tests he used were: the Sequential Test of Educational Progress (STEP) Mathematics, STEP Science, and the California Test of Mental Maturity (CTMM) Spatial Relations, CTMM Logical, CTMM Numerical, CTMM Verbal, and high school class rank. The STEP tests can best be described as achievement tests, while the CTMM scales are typically called aptitude scales. He found that one discriminant function was sufficient to account for 88% of the variance accounted for by the tests. Rank in class and the STEP Math had the highest loadings in the discriminant function suggesting that the remaining scales were highly interrelated and contained information that was not different from that provided by the STEP Math and rank in class. Essentially the discriminant function organized the four groups along a continuum in such a way that the two college-bound groups were higher in the constellation of measured aptitudes and achievements than the two non-college-bound groups. When the PSP group was dropped from a reanalysis, he found that the CNS group appeared to come from the same multivariate population as the non-college group, leaving the differences among the three groups to be explained by other factors. When Cooley combined his domains of temperament, abilities, and interests, he found two discriminant functions. One differentiated non-college-bound students (NCNT, NCT) from the two college groups (PSP, CNS). The class rank variable was the only important contributing variable in the latter function, being positively related to science orientation for both college and noncollege groups. High school rank was second only to mother-father educational expectations for son in separating the college attenders from nonattenders. In this case it would seem that high parental expectations, combined with appropriate interests and high rank in class will effectively predict science group membership at the 3rd year after high school (70% hits).

Project TALENT is probably the most comprehensive longitudinal testing program undertaken in the history of educational research. In their first major report (Flanagan, Davis, Dailey, Shaycroft, Orr, Goldberg, & Neyman, 1964) they listed some 15 tests of aptitudes and 45 tests of achievements, a student information form, a student interest inventory, and a student activities index which were administered to their natural sample of high school students in 1960. Their results in using general ability or achievement history in predicting career choice were reviewed earlier; but because their analyses included achievement and aptitudes, we will further review their results here.

In their 1-year after high school follow-up study, Flanagan and Cooley

(1966) found that SES, aptitudes, and abilities differentiated between those who went to college and those who did not (Schoenfeldt, 1966; see also Warren, 1971). The question raised is: Given the homogeneous nature of the remaining college-bound groups, can prediction of career choice be reliably made? Cooley (1966b) attempted to answer that question.

He first established that students with different characteristics go to different colleges, then looked at differences among students with different college majors. In the discriminant analysis he used 10 variables from each of three domains—ability, interest, and temperament. In the achievement domain he used tests of music information, social studies information, physical science information, sports information, creativity, mechanical reasoning, abstract reasoning, verbal composite, quantitative composite, and socioeconomic status. In the aptitude domain he used tests of memory for sentences, memory for words, disguised words, word function in sentences, reading comprehension, creativity, mechanical reasoning, visualization in three dimensions, visualization in two dimensions, abstract reasoning, arithmetic computation, table reading, clerical checking, object inspection, and preferences. The college majors used as criterion groups for men were mathematics, physical science, biological science, social studies, English and literature, languages and fine arts, psychology, education, engineering, business, and agriculture and forestry. The same categories for women were used except math and physical science were combined to form one group and engineering and agriculture were dropped and replaced by nursing and home economics. When using the tests from all three domains in his discriminant analysis, he observed two large functions accounting for 60% of the variance for the female and 70% for the male majors. The total math score, an achievement index, was the only ability score entering both functions for men and clearly helped separate the engineers, mathematicians, and physical scientists from all other male majors in the second function. In the first function it helped separate the agriculture and forestry majors and engineers from the remaining groups. For the women's groups only one cognitive test, math information, carried any weight in one of the two functions; it helped separate the sciences from the nonsciences. However, in all four functions interests played a greater role in the discrimination of the groups than did the cognitive tests.

In studying the predictability of changes in career objectives, Cooley used the original 9th-grade sample of boys as subjects. In this analysis he placed the follow-up expressions of career choice in one of six criterion groups (physical science, medicine-biology, humanities, business college, technical, and business noncollege) which broke down into 36 career plan change groups. For example, one of the 36 groups was those boys choosing a physical science career in Grade 9, but changing to a medical-biological career at follow-up. Thus, by classifying changers and attempting to discriminate among the 36 change groups, he could observe the weights of his predictor variables. In this case the ability measures carried more weight in discriminating among the groups than did the interest measures.

What happened after all the changing and persistence between the 9th grade and 1 year after high school? When Cooley used 19 ability measures to predict future plans, still classified into six categories, the measures produced two major functions. The first was a measure of general scholastic achievement and ranked the centroids of the six groups in the following order: physical science, biological science, humanities and business-college, business noncollege, and technical. In the first function only one aptitude variable, reading comprehension, made a significant contribution to the equation outcomes. The second function defined a continuum from high math ability to verbal and located each of the six groups on it. As in the first function, the physical sciences had the highest centroid, followed by the technical, the business noncollege, the medical-biological, and the business and humanities. In this function, aptitude measures had the highest relationship to membership in the science-technical groups. The two variables with the greatest weights were mechanical reasoning and visualization in three dimensions. Achievement scores in physical science information, mechanical information, and mathematics were also important to membership in the science-technology groups. Thus, the second function relies on specialized knowledges and aptitudes to provide a science-other directional dimension of career movement. And accordingly it illustrates the role of general ability in establishing level of career choice and the role of aptitudes and specialized achievement in the field of career choice.

In the ability discriminant function he observed a 38% hit rate, lower than the students' self-prediction of 42%. Cooley concluded (p. 204) that "Although the ability measures increased in validity from Grade 9 to the follow-up study while the motive measures decreased, the motive measures were still slightly better predictors of the follow-up plans."

H. S. Astin (1967a, b, 1968, 1970) found similar patterns in the role of TALENT aptitudes, but because she concentrated on high levels of occupations in her criteria, the results are not as clear - cut as Cooley's.

During the high school years, aptitudes and other response variables to be reviewed later begin to exert a directional influence on career paths and continue to do so after high school, although it now takes a 3-dimensional measurement space to describe the differences among 12 criterion groups (Cooley & Lohnes, 1968). The role of specialized knowledge in mathematics in separating the high-level science-related occupations from the others was discussed in the previous section on achievement. The aptitude of visual reasoning was one of the most powerful variables in separating the technical occupations from the sociocultural, even though the other types of measures were better predictors of career choices overall.

In summary then, we have seen how future scientists tend to be of high general ability and, by the time they are out of high school, tend to evidence high achievement in mathematics and science with aptitude for mechanics and spatial visualization. Precisely how the variables affect development has not been adequately studied although the research by Herriott (1963) and Davis (1964b) and others are suggestive. As the difficulty level of the subject matter increases, those who are less able to compete leave that path for another. The perception of inadequacy can come from comparing oneself to his peers or, if that is not sufficient, grades may deflect one from his goals. The degree of sorting out of students from the sciences results in a moderate rate of predictability of career development through the collegiate years; predictability based on aptitudes, ability, and achievement is no better than self-predictions of subjects. Career paths and their choice are not determined by aptitudes and ability alone. One of the thrusts of future research in this regard might most profitably be like that of creativity research (Taylor & Barron, 1963) which concentrates on the content and processes of the intellect as they relate to career development.

Interests

We have already seen some evidence of the importance of interests as predictors of vocational choice. The Project TALENT studies (H. S. Astin, 1967a, b, 1968, 1970; Cooley & Lohnes, 1968; Flanagan et al., 1971; Flanagan & Cooley, 1966) all employed what were called information tests in their discriminant analyses among occupational choice groups. These tests are very similar to what Super and Crites (1962) called tested interests as opposed to inventoried, manifested, and expressed interests. In each of the previously cited studies, the information variables tended to be important discriminating variables.

Interests are contrasted with abilities in the following way (Campbell, 1971):

> although a man's performance on the job depends on his abilities and motivation, whether or not he stays on the job will largely reflect whether he likes or dislikes it. For this reason, interest ratings are better indices of job persistence than success. [p. 2]

But from what we have already learned from the TALENT studies, H. S. Astin (1967a, b, 1968, 1970), and a host of others, the role of interests in direction and persistence is not as clear as Campbell suggests. Ability level and aptitudes are also related to direction of choice and to persistence.

According to this functional view of interests, they are defined as likes and dislikes, a global aspect of personality. The formation of interests has been traced to early childhood experiences (Roe, 1957b; Roe & Siegelman, 1964; Tyler, 1964) and lies almost exclusively in the domain of counseling and vocational psychologists. Recent work by Cole and Hanson (1971) suggests that there may be an underlying structure of interests which the most-used interest inventories tap.

Super and Crites (1962) identified four ways of measuring interests: (a) expressed, (b) manifested, (c) tested, and (d) inventoried. Expressed interests are verbal or written statements about an object such as an occupation. Manifested interests are determined by watching activities a subject pursues on the assumption that people do what they like and avoid what they do not like. Tested interests are determined by testing for knowledge about an object assuming that the more interest one has in something, the more he will know about it. Inventoried interests are derived from responses to an empirically-based instrument which asks respondents to identify their likes and dislikes in a systematic way. We will consider each approach as it relates to the choice of science or technology.

Expressed Interests

In this section we are asking the question: how early do students begin to express an interest in science and technology and can we predict from those expressions the future career development of the subject? One of the problems which quickly surfaces in the study of vocational choice is the instability of those choices, particularly in the early school years. Changes in the expressions are an integral part of the maturation process regardless of which theoretical orientation one adopts (Osipow, 1968). Nevertheless, we are concerned about the usefulness of expressions of vocational choice for predicting future vocational choices.

In the early studies of scientists (Visher, 1948), and in Roe's (1953) and Eiduson's (1962) clinical studies, the subjects report an early interest in science, and in some cases stated their choice was made before they were 15 years old. However, the typical period of commitment to the occupation was during college.

When one uses subject-matter preferences as an index of expressed interest (Krippner, 1963), it appears that for boys a general interest in science develops as early as the 6th, 7th, or 8th grades, particularly among high-achieving males. As the students continue their school career, a dimension of science interest and achievement level is predictive of enrollment in college preparatory curricula in high school (Cooley & Lohnes, 1968; Williams, 1968) all providing evidence of a general orientation toward science before beginning high school.

Whitney (1969) and others (Berdie, 1960b; Dolliver, 1969; Campbell, 1971) have reviewed the predictive validity of vocational choice as compared with inventoried interests, while others (Watley & Nichols, 1969a) have looked at trends in vocational choice over time. H. S. Astin (1967b) reviewed four major longitudinal studies to identify consistent patterns of change in career choice over time. She concluded that the choice of business and educational occupations gain in popularity over an 8-year period from the 9th grade to 4 years after leaving high school, while science and engineering decline in popularity over the same period.

In Project TALENT 1-year follow-up study Flanagan (1966) looked at the stability of career choice. The data he reports were based on the total weighted sample first tested as freshmen, sophomores, juniors, and seniors in high school and followed-up 1 year after their class graduated from high school. The shorter the period of time between the original assessment and the follow-up, the greater the stability of expressed interest as reflected by the subjects' selection of careers from among a list of 31.

Between the 9th grade and 4 years after school 16.8% of the men and 26.1% of the women chose the same occupation. The average stability rate between the 9th-grade expression of interest and the follow-up was exceeded only by those choosing engineering (18%) among the science-related occupations. For males the percentages of identical choice were: (a) mathematicians 3%, (b) physical scientists 10%, (c) biological scientists 3%, (d) psychologists, sociologists 10%, and (e) engineers, scientific aides 4%. The differences between the overall stability rate and that for science-related occupations was greater for women than for men. The female stability rates were: (a) mathematician 2%, (b) physical scientist 4%, (c) biological scientist 2%, (d) engineer 2%, (e) psychologist, sociologist 7%.

Although the pattern of stability of science interest remained similar for the 10th-, 11th-, and 12th-grade subjects, girls were more stable in their interests or choices than the men except for science-related interests. Results suggest that the predictability of development of occupational entry from expressed interests differs for men and women.

Cooley (1966b) reclassified the occupational choices of Flanagan's male 9th-grade subjects into six groups in an attempt to predict career plan changes 1 year after high school. He compared the usefulness of career choice prediction by students' earlier expressed choices to the predictions by measures of ability by measures of motivation. Forty-two percent of the students first tested as 9th graders had 13th-grade career choices in the same occupational groups of physical science, biomedical science, nontechnology nonbusiness, nontechnology business, science noncollege, or nontechnology noncollege. Neither the motive nor ability tests were better predictors. By grouping the choices to reflect relative magnitude of change, substantially more stability was apparent than was reported by Flanagan. A change in choice from physics to mathematics is not as great a change as one from physics to English teacher. By grouping the interests into categories somewhat like the common elements in interest inventories (Cole &

Hanson, 1971), the stability of the college-science occupational choices are close to the average stability rate, around 40%.

H. S. Astin (1967a, 1968) used Project TALENT data to investigate the changes in career choice during the high school years. In her study (1967a) of development, she used 9th-grade test data and career choices and 12th-grade career choices for 650 boys. The career choices of the subjects were placed in one of seven categories (business, engineering, science, education, professions, noncollege, and unclassified). In the 9th grade 21% of the boys chose engineering and 9.0% chose science occupations; as seniors in high school 16.3% and 6.1% made the same selections, a decline of 4.7% and 2.9%, respectively. She used discriminant analysis to investigate the value of number of antecedent variables in predicting the senior year career choice for the same 650 male subjects. The analysis produced five functions with 9th-grade expressed career choice or interest entering four of the five functions as important predictors. The first function, separating engineering choices from noncollege and unclassified choices, used the 9th-grade choice of engineering as its highest weighted variable. Thus, for males, expressing an interest in engineering in the 9th grade is closely related to making the same choice as a senior. The fifth function, the one with the least additional discriminating power, separated the science career choices from the teaching choices; expressing an interest in scientific occupations as a high school freshman was more related to making the same choice as a senior than to choosing a teaching occupation. However, this was not true when, in the fourth function, science was separated from the professions. That is, those choosing professional and scientific careers as seniors were equally likely to choose scientific careers as freshmen. If we consider the freshman year choices as interests, and also the interest inventory scales and the information tests, except for the total score, as measures of interest—expressed, inventoried, and tested, respectively—the dominance of interest in all five functions is clear. Over half of the variables with the largest weights in the five functions were interest related. Because of the nature of the discriminant function it cannot be said that the different measures are unrelated, but their importance in predicting subsequent career choices is obvious.

During the high school years there is a great deal of instability in specific career choices as we have seen from Cooley & Lohnes' (1968) study (also see H.S. Astin, 1967a & b, for a review of major studies); but if the choices are grouped, a good deal of stability is introduced. Moreover, if we attempt to predict future career choices, both H.S. Astin and Cooley have demonstrated that earlier expressed interests are important variables at least up to the last year in high school or 1 year beyond.

Cooley (1963a) wished to determine whether the same generalization holds true beyond high school to occupational entry. In the initial interview of 192 high school juniors, he obtained prediction from the subjects about what they would be doing 5 years afterward. The responses were classified into four groups: Prospective Science Pool (PSP), College Non-Science (CNS), Non-College Technical (NCT), and Non-College Non-Technical (NCNT) according to the expressions of career plans and current educational activities. He found that after 5 years 48% of the boys were in the same group as they were in the 11th grade. The 48% stability is comparable to his subsequent 42% stability rate in the 1966 Project TALENT report where he used six criterion categories instead of four. Twelve percent of all the 11th-grade subjects were always in the PSP group; 31% dropped and remained out of the group over the 5 years, while only 3.5% entered the group. Thus, as we have observed before, asking a high school student about his occupational choice does provide some one-way predictive information, but only about those making a choice, not for undecided students. It can be safely predicted that the student who expresses an interest in a nonscience career early in high school is very unlikely to end up a scientist. However, the opposite is not true. Given the percentage who change their expressed interests from science to nonscience, there seems to be little predictive validity established except for engineers and for differentiating between the college-bound and noncollege-bound (Cooley & Lohnes, 1968; Williams, 1967).

This is further supported by Astin and Panos' (1969) study of the educational and vocational development of college students. Their data gathering began with the large scale survey of 127,212 students entering college in the fall of 1961 and concluded with a follow-up of the original group after 4 years. Again engineering was the most stable choice (36.1%) with college professor (25.3%), chemist (20.0%), physicist (18.1%), biological scientist (14.1%), psychologist (10.7%), and mathematician (9.2%) following. The natural sciences and engineering again lost more people than they recruited. About half of those selecting one of these two fields as a freshman choice made the same choice after 4 years of college. Astin and Panos used multiple regression analysis to study the predictability of final career choices. In each and every category of choice (p. 98) "the student's chosen career at the time he entered college proved to be an important and accurate predictor of his career choice 4 years later; in fact, this variable carried the largest weight in seven of the equations and the second largest weight in the other five." Although the multiple correlation coefficients ranged from .201 to .530, the predictability was most generally accounted for by previous career choice which carried more weight than the ability measure of high school average, socioeconomic status, parental income, and a host of other background variables. This suggests that asking a freshman his career plans or expressed interests efficiently gathers a great deal of information about him.

Richards (1971c) computed Phi coefficients between career choice of 11th- and 12th-grade Project TALENT subjects and their career choices 5 and 6 years later. The computed Phi's all fell below .54 for nursing chosen by women, with engineering having the highest among the sciences (around .30) and the correlations between expressed choice and criterion choice were only slightly lower in general than the point biserial coefficients between all the TALENT tests and final career choice. Had Richards grouped the career choices into fewer categories than his 37, the Phi coefficients probably would have been increased. Unlike Berdie (1960b) and Whitney (1969), Richards concluded that expressed interests were not uniformly equal in their predictive validity to empirically-based predictions.

The evidence suggests that predicting expressed interests from previously expressed interests is generally tenuous and is primarily a function of the classification scheme used in organizing the vocational choices. When more than six or seven categories are used, the relationship between previous choice made more than a year earlier can be expressed as correlation coefficients ranging from .0 to .3 at best. When fewer than six or seven categories are used, the correlations will be somewhat higher. It is also true that the time between original assessment and follow-up affects stability (Holland & Lutz, 1967).

How useful are expressed interests in predicting actual occupational entry? Strong (1953) reported the results of a 19-year follow-up of 306 Stanford University freshmen who expressed a vocational choice in 1930. The criterion was the actual occupation the men were engaged in 19 years later. Using 12 occupational categories, he found that 38% of the 202 subjects responding in 1949 were engaged in an occupation corresponding to their 1930 choice. When the stability rate of the sciences was compared to the total stability figure, only engineering had a higher stability rate. Fifty-three percent of those originally expressing an interest in engineering were engaged in the occupation 19 years later. The remaining sciences were lower: for geologists it was 28%, for physicists—0%, and for chemists—28%. By weighting the occupational choices and occupational change to reflect changes to fields of a similar nature, he calculated a .69 correlation between freshman choice and occupation 19 years later.

A number of other studies (D. T. Dyer, 1939; Fryer, 1931; Holland & Whitney, 1968; McArthur & Stevens, 1955; Elton & Rose, 1970; Sisson, 1938) and reviews (Dolliver, 1969) have examined the predictive validity of expressions of interest as compared to inventoried interests, but they did specifically study sciences. However, if their relative predictive efficiency was similar to Strong's, we are probably less able to predict entry into a science occupation than into other fields. The reasons may include the relatively high defection rate from the sciences (H. S. Astin, 1967b) as compared to other career fields. Other problems in the area of prediction from expressed interests include attrition of subjects, sampling, and instrumentation-treatment interactions (Dolliver, 1969).

The instability of expressed interests and their moderate value as predictors over extended time periods cast doubt on the identification of future scientists via expressions of interest. However, their relative importance in prediction for shorter periods means that they may be helpful in plotting career trees (Cooley & Lohnes, 1968). Cooley (1963a), Cooley and Lohnes (1968), and O'Hara (1967) report that there seem to be two points in the careers of future scientists and young people in general when new heights of stability of expressed interests are reached. One comes around the beginning of the 11th grade and the other occurs after entry into college. Such an observation is in keeping with those developmental theories which specify that experiences provide an opportunity to test oneself against reality. The stability points occur shortly after the students reach a major decision point and when after they have experienced new situations in the normal sequence of education (Tiedeman & O'Hara, 1963).

Tested Interests

There has been less focus on tested interests than any other kind. The greatest concern with tested interests occurred during World War II (Super & Crites, 1962, p. 379) and shortly thereafter. Aside from the Project TALENT information tests, no other use of tested interests was found in our literature search.

Flanagan et al. (1964) describing the Project TALENT information, indicates that it:

> tests level of information in various academic areas, in general vocabulary, and in information of various types acquired in out-of-school activities. (p. 1-4)

For those information tests on academic subject-matter areas there was a high relationship between interests and an academic achievement factor (Flanagan, 1964, p. 2-122); this was not true for the information tests in the nonacademic areas.

If the information tests, which were intended as achievement tests, tap interests or motivation as Flanagan et al. (1964) state, they may be related to vocational development. The information tests included were:

1. screening
2. vocabulary
3. literature
4. music
5. social studies
6. mathematics
7. physical sciences
8. biological sciences
9. scientific attitude
10. aeronautics and space

11. electricity and electronics
12. mechanics
13. farming
14. home economics
15. sports
16. arts
17. law
18. health
19. engineering
20. architecture
21. journalism
22. foreign travel
23. military
24. accounting
25. practical knowledge
26. clerical
27. Bible
28. colors
29. etiquette
30. hunting
31. fishing
32. outdoor activities
33. photography
34. games
35. theatre and ballet
36. foods
37. miscellaneous

In the 1-year follow-up study (Flanagan & Cooley, 1966) Cooley investigated the predictability of career plans 1 year after high school from 9th-grade measures of ability and motivation. The career plans of the subjects were placed in one of six fields (Physical Science, Biological-Medical Science, College Nonbusiness, College Business, Noncollege Science-Technology, and Noncollege Nontechnology). Discriminant analysis was used to investigate the predictability of the career plans of the 45,215 subjects responding to the follow-up—37% of those originally tested as 9th graders. Two functions accounted for 93% of the variance accounted for by the 23 ability measures. In the first function which separated college-bound from the noncollege-bound, five of the nine variables with high loadings were information test scores—social studies information, mathematics information, literature information, physical science information, and music information—associated with locating the physical science and medical-biological centroids at the extreme of the dimension. The second function separated the physical science and technological areas from the remainder; here five of the eight variables with high positive or negative loadings were information tests. Mechanical information, physical science information, and mathematics information had positive loadings, while sports information and literature information had negative loadings. Apparently, the less information (or interest, in our definition) one has in sports and literature in the 9th grade, the less likely he is to express an interest in a career in science or technology one year after high school.

Using TALENT data, H. S. Astin (1967a & b, 1968, 1970) found a similar pattern of predictors for men and women. Information tests were frequently highly-weighted predictors in her discriminant analyses, with mathematics information and mechanics information being positively related to science or engineering while literature information was negatively related to these choices.

Of course the difficulty in claiming their information tests as interest measures is evident. In fact, those information tests which related to choice were those Flanagan et al. (1964) found to be highly related to other cognitive tests, while the nonacademic information tests were not related to career choice. Although we cannot conclude that tested interests are not related to vocational or career development, such a relationship has not yet been established in the sciences.

Manifested Interests

Manifested interests come from behaviors actually exhibited or observed. The measurement of manifest interests comes from two sources: observation and self-report, and takes the form of hobbies and school curriculum programs or college majors.

One of the measures of manifest interests which proved to be a powerful predictor of scientific orientation was teacher ratings of student activities found in Cooley's (1963a) Scientific Careers Study. The four groups he used will be recalled from earlier discussions: PSP, CNS, NCT, and NCNT. Teachers of the 192 Grade 11 subjects, described the extra-class scientific activities of the boys. Two activities were of importance: if the boys spent extra school time engaged in science-related activities and if the boys did individual research projects. Both the PSP group and CNS group spent more time in science-related activities than did the noncollege groups. However the PSP group was considerably more likely to engage in individual research than any of the other groups. Cooley also asked the teachers to predict whether or not the subjects would be in the PSP group two years after high school; 74% of the predictions were correct. Thus, while the two science-technology groups (PSP and NCT) had similar patterns of inventoried interests, manifest interests were better predictors of group membership after 5 years.

Eiduson (1962) disputes Visher's (1948), B. L. Raskin's (1968) and others' conclusions that future scientists express their scientific interests at an early age through use of chemistry sets and other outlets of manifest interests. Cooley's results are not specific to this question, but do indicate the importance of manifest interests in predicting science orientation.

The same was not true of the high school courses his subjects took. There were no differences among his four groups in the number of semesters of mathematics taken, whether or not physics was taken, or number of foreign languages taken although all were originally enrolled in the college preparatory curriculum.

College majors would appear to be an adequate measure of interests, but as we have already seen they tend to be unstable, particularly majors in the sciences. But is graduating major field more predictive? Do students going into graduate school or seeking employment do so in fields identical to their graduating major?

Schwartz (1965) in her study of the college-educated population from the 1960 census enumeration sampling frame compared the field of highest degree and field of occupation. Among engineers 85% to 92% of those in the survey took their highest degree in engineering. Only 14% of the BA holders in mathematics were engaged in that field, while 61% and 80% of those whose highest degree was a math master's or PhD, respectively, were engaged in mathematical or statistical work. Those working in physics had the same pattern. Fewer (18%) of those with the BA, more of those who had earned the masters (55%), and still more of those who had the PhD (76%). Forty-seven percent of those whose highest degree was a BA in chemistry were engaged in chemistry while 45% whose highest degree was a chemistry MA and 90% a chemistry PhD were employed in the field. The pattern continues throughout natural sciences. Between 75% and 90% of those with a PhD in the sciences were employed in the sciences. Fewer of those with their highest degree at the master's level in the sciences were engaged in scientific occupations. The lowest percentage was 35% for the biological sciences and the highest was 87% for "other" physical sciences closely followed by engineering (84%). About half of those whose highest degree was a BA in chemistry were chemists while only 14% with a BA in math and no further degree work were mathematicians. One of the more interesting comparisons was among the natural sciences, the social sciences, and teaching. Graduating with a BA in psychology or another social science major and no further education makes a perfect prediction for occupation in another field. This is less true for the natural sciences and exactly opposite for engineering and elementary teaching. With the exception of secondary teaching, psychology, and agriculture, three-fourths or more of those receiving a PhD will enter an occupation which corresponds to their graduate field of specialization.

L. Harmon & Boercker (1967) give a different perspective. Of those with physical science PhDs, 93% received their BA in a similar field. For those in the biological sciences 75% received their BA in a like field. And 64% of the PhDs in the social sciences received their BA in a social science field.

Sharp (1970) reports on the follow-up of a cross-section of June 1958 college graduates two years after they graduated and again in 1963. Her original sample had 32,000 respondents in the first follow-up; a subsample of those was selected to be included in the 1963 survey. Of her 16,293 men and 9,290 women, not much more than a third (44.0% and 22.1%, respectively) were in graduate or professional school between 1958 and 1963. Those in the natural sciences (biological, premedicine, chemistry, earth science, physics, other physical science, and mathematics) as undergraduates were more likely to pursue an advanced degree than any other group. The average proportions were 60.0% for men and 29.3% for women. The social sciences were next highest with 52.0% and 28.0%, with the humanities almost equal at 53.3% and 26.3%. These data suggest that students majoring in a natural science are more likely to go on for an advanced degree than are students studying other fields. When relating undergraduate major to occupation by sex of the subjects, the sex bias is clear. For women, teaching was the modal occupation regardless of major field except for those in the health professions (nursing). For men there was little relationship between majoring in social science and being a social scientist, while there was moderate relationship between majoring in science and being employed in the sciences except in engineering where the relationship was extremely high. One half of Sharp's male subjects with an MA in a natural science were engaged in a similarly-classified occupation. Other MA fields and the percentage of men employed in them were engineering 75.3%, social sciences 23.5%, humanities 18.3%, health 37%, business 64.9%, education 87.6%. Comparable figures for women were 27.1% for natural science, 17.0% for social sciences, 14.5% for humanities and arts, 64.7% for health, and 82.6% for education. The grouping of undergraduate fields in Schwartz's (1965) study masks some important differences among fields in the same class, making it difficult to compare her data with Sharp's. However it does seem that the two studies are in agreement regarding patterns of undergraduate and graduate major. That is, the more advanced the degree, the more likely the student is to enter an occupation directly related to his specialized field of study. However, with the exception of the health fields, the same is not true for women because of the dominance of teaching.

Like expressed interests, manifest interests tend to be fairly unstable for the first two years in college. Yet they may be the best single predictors of vocational choice or development available. However, a more reliable way of assessing interests is through inventories specifically developed for this purpose.

Inventoried Interests

Like ability and aptitude testing, there have been many concurrent validity studies to measure interests of subjects according to their occupation or some other expression of vocational choice. Super and Crites (1962) discuss several approaches to the measurement of interests including factor analysis, item analysis, theoretical, and in some cases plain arm chair conceptualization. Cole and Hanson (1971) have demonstrated that at least among the most popularly used inventories, there appears to be, regardless of the methodology, a common underlying structure used to construct and validate the instrument. Validation of interest inventories has traditionally involved identification of subjects with different attributes or different activities, giving them the instrument, and seeing if it discriminates among those subjects with the different attributes or different activities There has been a large amount of research in this vein (Buros, 1972); we will focus on that which is predictive in nature.

Tyler (1964) followed 287 subjects from the 1st grade to adulthood to observe changes in interests, special abilities, and personal-social characteristics. As 8th and 12th graders the subjects were given the Kuder Vocational Preference Record—Vocational and were classified into one of two groups based on their 12th-grade Strong Vocational Interest Blank results. Those with high interests in Biological and Physical Sciences (primary pattern in Groups I and II) were called the Scientist group. Those subjects with very low interests in the same areas (reject patterns in Groups I and II) were placed in the Nonscientist group. The inventoried interests gathered by the Kuder were, like the ability and personality measures given during the early school years, unrelated to group membership as high school seniors. However compared to the nonscience group boys in the science group had higher masculinity scores in the 8th grade, meaning a greater liking for activities preferred by men. In a more intensive look at the activities the science group liked, Tyler found that the main characteristic which separated the two groups was an actual interest in scientific activities, while there were no differences between the two in ability or background variables. On the basis of their interest inventory results, she divided her female subjects into: those with a career orientation and those with a noncareer orientation. Those oriented toward a career had higher masculinity scores earlier in their life than did the noncareer-oriented girls. Thus we observe an early emergence of preferences for masculine activities for young boys who later have dominant interests in the sciences and for the girls who are career-oriented. The observations of early emergence of masculine interests for boys with high science interests and girls with career interests brings to mind the research on parental influences on the development of interests. There has been some work on the relationship between parental identification and similarity of interest patterns between one or both parents and the offspring, particularly with regard to masculinity-femininity (Crites, 1962; Heilbrun, 1969; Hollender, 1972; Lynn, 1969; Steimel & Suziedelis, 1963; L. H. Stewart, 1959; White, 1959). Apparently identification with one or the other parent affects interest development in different, but not fully-understood ways. Some of the results suggest that an early emergence of highly masculine interests may be a function of identification with either a "masculine" father or "masculine" mother, but at this point it can be considered nothing more than a supposition.

The Kuder Preference Record—Vocational, Form CM was used as an 11th-grade instrument in Cooley's (1963a) Scientific Careers Study. This 5-year overlapping longitudinal study is the same as has been discussed before and a review of its details will not be repeated here. The 10 scale scores from the Kuder Preference Record were used as predictors of group membership four years after high school graduation. He found that two discriminant functions were necessary to describe the differences among the four groups. The science-technology (PSP and NCT) groups were separated from the two nonscience groups by one function, and the second function separated the college (PSP and CNS) from the noncollege subjects (NCT and NCNT). There are 10 scales in the instrument, of which the scientific interest scale was most predictive of membership in either the PSP or NCT groups in combination with low scores on the clerical interests, persuasive interests, social service, and outdoor interest scales. A reversal in pattern, that is a low science interest coupled with a high interest in the other areas, would be predictive of membership in either the NCNT or CNS groups. On the second function, which separated the college attending from noncollege attending groups, high science and social service interests with low interests in mechanical and artistic areas were related to college attendance. Therefore it would seem that the combination of high interest in science activities, low interest in clerical, persuasive, and outdoor activities, and low interest in persuasive and mechanical areas is predictive of development toward a college-science program. The same pattern of interests but with high interest in mechanical activities would be predictive of technical group membership. In his interests classification matrix Cooley was able to correctly classify 50% of his subjects. Cooley also administered the Strong Vocational Interest Blank to his subjects when they were in their 4th year after the initial assessment, when the criterion group membership was determined. Results similar to those obtained with the Kuder were observed with two discriminant functions. The PSP and NCT groups showed similar patterns of interest on the first function (high technical or physical science interests and low business detail); a second function was needed to separate the two. When work values were added to the discriminant function, he correctly placed 64% of his subjects in their criterion groups. When he compared different predictor systems (ability and aptitudes, interests, temperament, SES, parental expectations), the discriminant analysis resulted in two functions serving the same purposes that recur throughout his study. High class rank, high science interest, high logical aptitude combined with high parental expectations, and mother's education would place a student in the PSP group. The NCT group would be composed of those students with high class rank, science interests, mechanical interests, and low parental expectations.

He correctly placed 67% of his subjects with the overall discriminant analysis.

In his review of the predictive validity of the Strong Vocational Interest Blank's occupational scales, Campbell (1971) concluded that prediction to specific occupational entry, say 8 to 10 years after high school, from a high school administration of the Strong is risky. The best that can be done is to predict general direction of development by occupational field. He concluded that:

> After age 25, people's interests appear to change very little; between 20 and 25 some mild changes may appear, but the usual finding is one of considerable stability; between the ages of 15 and 20 there will be some people whose results show considerable change (p. 86).

In view of Tyler's (1964) results and Crites' (1969) conclusion that rate of vocational development is related to SES and ability levels, a question of the early crystallization of science interests is raised. That is, are the interests of future scientists and technicians more or less stable than the population in general. It could be hypothesized that their interests would stabilize earlier than other students. However, in view of Project TALENT results the stabilization rates appear to differentiate the college bound from the noncollege bound rather than various career development patterns within the two groups.

Although Project TALENT did not analyze the relationship between early masculine interests and development of its subjects, aside from the work done with the Strong Vocational Interest Blank, it included the most extensive look at prediction of development by inventoried interests.

One of the primary objectives of their 1-year follow-up studies (Flanagan & Cooley, 1966) was the prediction of vocational and educational development from data collected when subjects were freshmen, sophomores, juniors, and seniors in high school. One part of the assessment program was an interest inventory yielding scores on 17 scales: (a) physical science, engineering, and mathematics; (b) biological science and medicine; (c) public service; (d) literary-linguistic; (e) social service; (f) artistic; (g) musical; (h) sports; (i) hunting and fishing; (j) business management; (k) sales; (l) computation; (m) office work; (n) mechanical and technical; (o) skilled trades; (p) farming; and (q) labor. As the scale names suggest, some scales were devised to tap vocational interests and others avocational interests. Cooley (1966b) investigated several questions in predicting development. First he looked at the predictability of students' Grade 12 vocational plans from Grade 9 measures, then at the predictability of changes in plans, and finally at the predictability of plans made 1 year after high school from Grade 9 measures. In the investigations he used a six-fold classification scheme of plans which included college physical science, college biological science, college nonbusiness, college business, noncollege science-technology, noncollege nontechnology. The subjects' career plans in the 9th grade, 12th grade, and 1 year after high school were placed in the appropriate category. When Grade 9 plans of 5,857 males were cross-classified with their career plans 1 year after high school, 42% of the subjects' career plans had not changed. Of the 2,379 choosing a physical science career in Grade 9, less than half (965) had the same plans four years later, while 342 boys changed from another field to physical science. The determination of changes in career plans as they related to the 50 TALENT measures resulted in some interesting patterns. For example, almost all of the ability measures were associated with changes to a career of similar ability levels and patterns, i. e., in terms of abilities the groups were more homogeneous 1 year after high school than they were based on the Grade 9 plans of the same subjects. Cooley stated it another way:

> ability measures were more highly related to what would happen than to what was currently planned, whereas motive measures appeared to be more related to current plans than to future plans. (p. 186).

In an elaboration, he noted that the mean physical science interest score, a motive measure, was unchanged from Grade 9 to the follow-up for the physical science groups irrespective of the high attrition rate over the 5-year period. Thus, the stability of a career plan toward physical sciences was independent of interest in physical sciences at Grade 9. Accordingly, single scores on interest inventories at Grade 9 may reflect only perceptions of the field and workers in it and perhaps the student's success in mastering related learning tasks, all of which may, and apparently do, change during the high school years. In using the Grade 9 motive measures to predict group membership 1 year after high school, interest scales were more highly weighted in the discriminant functions than were need and life style variables. The discriminant analysis produced two major functions that were similar in effects to the two functions based on the 23 ability measures. The first function separated the college attending students from those not attending college, and the second separated the two science-technological groups from the nonscience-technological groups. The first function gave high positive loadings to physical science interests and biological-medical science interests, and negative loadings to skilled trades, labor, and mechanical-technical interests associated with college attendance (high on axis) or nonattendance (low on axis). In the second function mechancal-technical and physical science interests had high positive loadings while social service interests, sociability, and public service and literary-linguistic interests had negative loadings. As in his 1963 study of interest measures, an interest in mechanics and physical science seems to be associated with technical or scientific career plans, while a high interest in mechanics and low interest in science is related to noncollege plans. However, unlike previous studies, interest in business detail was not found to be inversely related to interest in science.

The observation of a science-oriented scholasticism which differentiated the college-attending students from the vocationally-oriented students was also found by Williams (1968) and was used as a partial basis of the career tree constructed by Cooley and Lohnes (1968). The career tree concept is a developmental approach to understanding vocational choice. In their tree, they identify five levels of development which parallel the structure of the educational system. The first level encompasses the period before junior high school, the second the period during high school, the third the high school years, the fourth 1 year after high school, and the fifth a 5-year period after high school. Within each level the decisions the subjects make or career plans they express are traced from level to level in a dichotomous branching scheme. For example, science-oriented students in junior high school can choose either a college-attending path or a noncollege-attending path. If they choose college, they can choose biological-medical or physical sciences and later are faced with a decision of advanced study in either professional or graduate school. Of course, as their development proceeds fewer options are open for the students, but the tree becomes very complex. The issues Cooley and Lohnes addressed were the predictability of the courses chosen at each level based on data gathered at preceding levels.

Although the tree had considerable path jumping, i.e., subjects whose career development proceeded in an erratic pattern which presumably was costly to the subjects, path following was dominant. A first discriminant analysis was designed to determine the ability of the TALENT abilities and motives factors to separate the subjects into 1 of 12 groups based on their 12th-grade career plans. The discriminant analysis resulted in three functions named science-oriented scholasticism, technical versus sociocultural, and business versus cultural. The two best predictors in the functions were scholasticism among the motives variables, and mathematics ability in the abilities domain. Science interests and verbal knowledge were also powerful predictors. The investigators point out (p. 4-65) "that all four interests factors are among the nine best predictors, but it is the pattern of interest scores that is important for each group, not any one interest by itself." The four interest scales were business, outdoor and shop, cultural, and science. Moreover the interaction of motives and abilities were needed to locate the subjects in the three-dimensional space.

As indicated earlier, virtually the same dimensions were found when Cooley and Lohnes predicted career plans of the 12th-grade subjects 5 years later, and identified path jumpers in predicting the direction of change. The importance of their work and its complexity have been discussed by Cooley (1967) and the results are difficult to summarize. However, it appears that two dimensions of personality, abilities and motives, are necessary and sufficient to predict the development of subjects. Furthermore the two dimensions of interests and abilities are useful in helping a subject explore courses of educational preparation leading to a career. However, as the authors emphatically state, their work and that which will follow are not (p. 4-5) "*so precise as to represent a prescription*" (italics in original) all of which was supported by H. S. Astin's (1967a & b, 1968, 1970) work using TALENT data.

What about the prediction of entry into a specific scientific occupation or related occupation using interest patterns from either recent or much earlier administration of a standardized interest inventory? Aside from the work just cited and that of Strong (1955) and others using the Strong Vocational Interest Blank (Berdie, 1960 a & b, 1965; Campbell, 1966a & b; Ferguson, 1960; L. W. Harmon, 1969; McArthur & Stevens, 1955) and establishing the predictive validity of the occupational scales for MDs, lawyers, accountants, journalists, dentists, mechanical engineers, architects, bankers, insurance agents, social workers (women), and lab technicians (women), there is little information about the predictability of scientific and technological occupations. The most frequently used interest inventories are the Strong Vocational Interest Blank, the Kuder Preference Record or Kuder Occupational Interest Survey, the Minnesota Vocational Interest Inventory, the Ohio Vocational Interest Survey (a newer instrument designed for vocational-technical students), and the Holland Vocational Preference Inventory. The last instrument is listed as a personality instrument, but we include it as an interest inventory here. The *Seventh Mental Measurements Yearbook* (Buros, 1972) lists 33 interest inventories and reviews extensively their controversial value. Because of the instability of expressed interests and career plans over a 2- to 4-year period, more research is needed both from the perspective of one stage to another (Ginzberg, Ginsburg, Axelrod, & Herma, 1951; Super et al., 1963) and from one decision point to another (Kroll, Dinklage, Lee, Morley, & Wilson, 1970; Tiedeman & O'Hara, 1963).

The validation of the Strong Vocational Interest Blank is described in some detail in Campbell's (1971) *Handbook for the Strong Vocational Interest Blank*. The occupational scales were validated against Men-in-General. That is, the instrument was given to men or women in specific occupations; if they had been in the occupation for more than 3 years and, in some cases, expressed satisfaction with their job, their patterns of responses were compared to Men-in-General (MIG), or for the women's form, Women-in-General (WIG). Of course an occupational scale cannot be established if there is not a sufficient difference in the patterns of response of those in the occupation compared to men in general, a rare but observed event. How well do the occupational scales differentiate? Those responsible for the instrument use a Q statistic which yields an estimate of the percentage of overlap in the patterns of responses between groups to demonstrate the discrimination power of the scales. The greater the percentage of overlap, the less the discriminating power of the scale. The percentage of overlap ranges from 51% for production manager to 15% for YMCA secretary with a median of around 30% for the men's scales. For the women's scales the range is from 51% for physical therapist and elementary school teacher to 14% for non-teacher with a mean of around 37%. The percentages of overlap for men scientists compared to MIG were 26% for radiologists, 24% for mathematicians, 23% for physicists, 36% for chemists, 45% for engineers, and 21% for psychologists, most of which were lower than the average of 30%. The percentage overlaps for women scientists were: 19% for chemists, 25% for engineers, 22% for mathematicians, 36% for medical technologists, and 24% for psychologists, most of which were lower than the average of 37%. Thus, in separating people in scientific occupations from MIG or WIG the inventory does somewhat better than the average scale. Do the scales discriminate among men and women in the sciences? Not as well as they discriminate between the sciences and MIG or WIG. For the men scientists the percentage overlap ranges from 31% to 55% and for the women 30% to 50%. An example of the difficulty in separating men in the science occupations is cited by Campbell:

> the physicists scored higher (mean=54) on the Chemist scale than the chemists did (mean=50); clearly the Chemist scale cannot be used to distinguish between the interests of these two occupations. Paradoxically, the Physicist scale did separate them rather well. Physicists average 50 on their own scale, whereas chemists averaged only 38; on this scale the percent overlap between the two occupations was roughly 55%. Just why the two scales give different results, and why the relationship is not symmetrical, is not understood (p. 48).

He goes on to relate that the overlap was probably not due to lack of concurrent validity but to similarity of interests among those in the occupations. Of course, if what Cooley (1967) and Cooley and Lohnes (1968) posits is true, we cannot expect a single interest score to differentiate among occupations. Differentiation comes when considering patterns of factors in the whole personality structure. Further, Cole and Hanson (1971) and others (Cooley & Lohnes, 1968) suggest that the measurement space occupied by interests may have fewer useful dimensions than that described by the Strong occupational scales. Recognizing that possibility, the Strong has been providing Basic Interest Scales for men and women.

The basic scales are based on similarities of patterns of responses regardless of the occupation of the subjects and are so new that the 22 scales are still being validated. Campbell (1971) does report that the differentiation among occupational groups is not as good as with the occupational scales, although there is some observed difference between salesmen and scientists. Moreover men scientists had higher scores on the mathematics scale and science scale, were fairly high on the mechanical scale, were low on the public speaking scale, but were not at the bottom of the office practices scale as they were in one other study (Cooley, 1963a). Women scientists scored high on the women's numbers scale (mathematicians, engineers, and chemists), high on the physical science scale, and low on the teaching and writing scales. Women technologists (laboratory technicians, medical technologists) scored high on the biological science scale. No definitive predictive data were available on the women's Basic Interest Scales.

We wish we could report other research of predictive or concurrent validity to the extent of that done with the Strong. Yet only concurrent validities of other interest inventories are available (see Buros' *Seventh Mental Measurements Yearbook*, 1972). The Vocational Preference Inventory (VPI) and the Kuder inventories have similar validities to the Strong except that the VPI, using fewer scales, has a remarkable record of differentiating students in different curriculum programs (Elton & Rose, 1970; Holland & Whitney, 1968; Holland & Nichols, 1964) and in predicting development.

The changes in the scoring procedures for the Kuder Vocational Preference Record to make it the Kuder Occupational Interest Survey (OIS) have resulted in some better concurrent validity data (Kuder, 1966). Rather than comparing responses to a general reference group, comparison is made to occupational groups and to groups of college students majoring in different fields. The OIS reports seven major scales and 23 occupational scales for which the median percentage overlap for men is 32 and 3[illegible] for the original criterion groups and crossvalidation samples, respectively. Based on the percentage of overlap figures (p. 32) the following was observed: (a) chemists were more like mathematicians than physical science majors, (b) electrical engineers were more like personnel directors and heating and air conditioning engineers than they were like electrical engineering majors, (c) mathematicians were more like chemists than electrical engineers or physical science majors. To be sure, these comparisons were made on the basis of one scale score, yet they offer two kinds of inferences. First, there is a decided tendency for occupational scales of related occupations to have higher overlap than scales for unrelated occupations (in this case relatedness is judged from Cole and Hanson, 1971). Secondly, when comparing the overlap rates between related occupational groups to the overlap between college majors the latter tends to be higher. Thus, some evidence supports Cooley and Lohnes' (1968) finding that interests tend to be more predictive of current plans and activities than of future plans and activities. The discriminatory power of the college major scales and occupational scales appears about equal.

Classification is one other kind of concurrent validity Kuder uses to support the inventory. Using a crossvalidation sample, he calculated the degree to which different occupational groups had their highest score on related interest scales. Again there was a tendency for the groups to score high on their own occupation and major scales and related scales. However, if compared on a dichotomous principle (high on own scale or not), they were about as likely to score high on another scale as their own. So again as Cooley and Lohnes (1968) suggest, patterns seem to be more important than individual scale scores even though some interesting differences are observed (Korn, 1962) in scale by scale comparisons.

Summary

Even though inventoried interests are not related to early directions toward science and technology, specific patterns of interests are related to specific outcomes of vocational development. By the time boys are ready to leave high school, orientation toward the sciences is well established. Girls do not present such clear evidence. The directional dimension of a career path seems to be a function of more than just interest patterns. It is not yet clear whether interest is the primary motivating factor for entry into and persistence in the path, although interest factors do seem to be more related to direction than are ability and aptitude factors.

The kinds of conditions that may be necessary for the emergence of a specific science-interest pattern are entirely clear. Certainly they include the environmental press variables discussed in the preceding chapter. Moreover, the consistent observation of two broad interest dimensions in childhood suggests that masculine or "thing" interests as opposed to feminine or "people" interests lead to careers in some science areas. The differentiation of interest patterns during the high school years seems to parallel the differentiation of vocational choices.

Like general ability, an interest in scholasticism acts as a force to establish the level of career choice; at the same time aptitudes and interest factors seem to act in concert to direct the choice toward a group of related occupations. However, cases such as Cooley and Lohnes' (1968) path jumpers appear to challenge this generalization. Although we know something about them such as their lower aptitudes and ability levels when compared to the group they are leaving, they tend to look more like the group they are leaving in terms of interests than the group to which they are attracted.

Personality

According to some definitions (Guilford, 1959; Hall & Lindzey, 1957) those topics already discussed as responses are an integral part of the concept of personality. Abilities, aptitudes, interests, attitudes, needs, values, temperament, physiology, and morphology all have been identified as aspects of personality. The various theoretical views of personality differ only in the conceptualizations of the structure and dynamics of those aspects. Although most theories of vocational choice are closely related to various personality theories (see Hall & Lindzey, 1957; Pervin, 1970), they differ widely in their theoretical ancestry (Osipow, 1968). The most frequently used theoretical bases are psychoanalytic, trait and factor, and ego or self theories, but there is a notable absence of purity in the theoretical formulations of career development. Some have no antecedent personality theory while others combine two or more. Cooley and Lohnes (1968), for example, merged the trait and factor approach with the developmental view. All this makes the review of the personality development of technicians and scientists somewhat difficult. However, we will begin with what we call the clinical approach, go to needs, then trait and factors, and then ego theory.

Clinical Approach

The clinical approach includes a mixture of theoretical approaches that have obtained similar results. Perhaps the best known clinical approach has been that of Roe (1946, 1949a & b, 1950, 1951a & b, 1952a & b, 1953, 1956, 1957a & b, 1961) which resulted in a theory of career development (Roe, 1957a; Roe & Siegelman, 1964). Osipow (1968, p. 17) has attributed her theoretical approach to Murphy (1947) and to Maslow's (1954, 1970) need theory. The instrumentation of her study of eminent scientists included interviews and two projective devices—the Rorschach inkblots designed for clinical diagnostic work and the Thematic Apperception Test originally developed for Murray's (1938) need-press thema as a device for psychodiagnostic work. Her findings implied that different personality patterns among biologists, physicists, psychologists, and anthropologists were attributable to parent-child relationships when her subjects were children. In a 1961 statement of the psychology of scientists, she concluded that (a) truly creative scientists seek experience and action; are independent and self-sufficient in perception, cognition, and behavior; and are highly egocentric; (b) they prefer apparent and resolvable disorder, have an esthetic appreciation of forms and experience, and have unusually high tolerance for ambiguity; (c) their strong egos permit them to regress to preconscious states and effectively control their impulses; (d) they have weak interpersonal relations; are not gregarious, talkative, or social; and tend toward femininity in men or masculinity in women; (e) they demonstrate a greater preoccupation with things than with people; and (f) enjoy taking the calculated risk if they have some control over the outcomes of the consequences and if the risk involves nature and not people. Social scientists were people-oriented, while physical and biological scientists were thing-oriented. However, her methods and sample sizes have been questioned by many as well as her use of psychodiagnostic instruments with little empirical support for their validity (Anastasi, 1968; Cooley, 1963a; Cronbach, 1960; and every Mental Measurements Yearbook—Buros, 1972). Yet, Eiduson (1962) using similar instrumentation studied scientists and uncovered similar patterns of personality.

Her analysis of the personality of scientists leads her to describe the scientist as one who: (a) has strong emotional leanings to intellectual activities,

(b) has a tendency to be independent of others, (c) is challenged by frustration and anxiety-producing situations, (d) is curious, (e) has a strong ego involvement in his work, (f) has capacity for sensual gratification, (g) is motivated by a desire to master and interpret natural forces, (h) is sensitive to moods and feelings of others and his internal environment, needs, wishes, and desires, (i) values work primarily as permitting the expression of inner personality. She also concentrated on the self-image of the scientist and found it to be one of nonconventionalism, originality, and broad intellectual development with a diversity of interests eschewing the "eccentric" conception of the scientist. Certainly such enumerations are not as psychoanalytic as Kubie's (1958), but they do lead to trait and factor approaches to describing the personality of scientists.

Emotion control also appeared as a discriminating factor in Field's (1954) study of 116 scientists who were recent college graduates. His sample consisted of 29 high-achieving and 29 low-achieving graduates, 29 physical science majors and 29 social science majors who were tested using a variety of instruments including the Blacky Pictures Test. The physical science majors had greater emotional control than did the high achieving graduates and the social science majors. They tended to be more "authoritarian" and more conformist than the other subjects.

Those who have applied psychoanalytic concepts to career development have tended to ignore the vocational development of technicians and scientists. The major problem faced by the analytical approach is that typified by Bordin, Nachmann and Segal's (1963) work in the occupation-by-occupation prescription of their modes and objects. The inherent instrumentation difficulties of analytical concepts (although not unattempted, Holland, 1968; Weinstein, 1953) and lack of enthusiasm for analytical work in general, account for the few studies in this area. Aside from Bordin, Nachmann and Segal's (1963) study, most clinical approaches have been oriented toward occupational differences and not toward developmental approaches.

Trait and Factor

The trait and factor approach to personality is a collection of research using a variety of instruments and conceptions. While some studies reviewed below have theoretical orientations different from trait and factor they are included here because, in our view, they are attempts to categorize subjects by their expressions of interest or vocational choice using observed differences in personality traits.

We begin our review with the familiar study by Cooley (1963a). One aspect of his overlapping longitudinal study was the use of the Guilford-Zimmerman Temperament (GZ) Survey. The GZ is a factor analytic-based instrument developed to assess Guilford's (1959) conception of personality as

(p. 5) a unique pattern of traits of an individual. The survey contains ten factor dimensions: General Activity, Restraint, Ascendance, Sociability, Emotional Stability, Objectivity, Friendliness, Thoughtful-Reflective, Personal Relations, and Masculinity of Emotions and Interests. In his discriminant analysis approach to predicting group membership (PSP, CNS, NCT, NCNT) 3 years after high school from Grade 11 assessment, the scales were not particularly discriminating. The college groups (PSP and CNS) had higher Restraint-Seriousness scores indicating they tend to be restrained rather than carefree, tend not to crave action or excitement, and are serious rather than unconcerned. The NCT group was lowest on the Restraint Scale while the PSP was highest. The two science-technical groups (PSP and NCT) had higher average scores on the Thoughtful-Reflective factor than did the two nonscience groups. Thus the science groups are more prone to like serious thinking, to analyze self and others, and to frequently meditate. The discriminant analysis resulted in two functions which did not discriminate well. When compared to the discrimination power of interest, ability, work values, teacher ratings, high school courses, and SES, the GZ was the least useful. Only the Rorschach had less discriminating power. However, the two GZ scales with significant differences were contributors to his overall discriminant analysis.

Cooley also administered the Allport-Vernon-Lindzey Study of Values (1970) to his 11th-grade subjects. This instrument was designed to (p. 3) "measure the relative prominence of six basic interests or motives in personality: the *theoretical, economic, aesthetic, social, political,* and *religious.*" The univariate analysis of variance revealed only two significant differences in mean scores among the four groups at the 3rd year after high school. The two science groups (PSP and NCT) had higher Theoretical scores (value science as search for truth rather than practical applications, take cognitive attitude in looking for identities and differences, and seek only to observe and reason) and the CNS group had a higher score on the Political Scale (interest in power and leadership) than did the other groups.

Project TALENT administered the Student Information Blank (SIB) to its subjects in an attempt to assess the "motives" domain of personality. We have already discussed their assessment of the interest domain and the life style as indicated by the socioeconomic status of the family. The remaining area they titled needs, following although not paralleling Murray's (1938) conception. From the Student Activities Index's (SAI) 150 behavioral adjectives they constructed 10 scales of needs modalities. They were: (a) Sociability (preference for social interaction, gregarious, group activities), (b) Social Sensitivity (concern for other's feelings), (c) Impulsiveness (doing things on the spur of the moment), (d) Vigor (physical activity), (e) Calmness (nonexcitable), (f) Tidiness (called order in the EPPS, orderly environment), (g) Culture (good manners), (h) Leadership (elected offices in student groups), (i) Self-Confidence (at ease with others), and (j) Mature Personality (responsibility).

In predicting work patterns and college majors in their 1-year follow-up studies (Flanagan & Cooley, 1966), they used only the interest and ability measures; therefore, we have no information on the possible contribution of the needs domain to prediction of college major or work patterns. When Cooley (1966b) studied the predictability of changes in career plans, he used the entire array of assessment variables. The study, reviewed earlier, was an investigation of the predictability of changes in career plans one year after high school for males originally tested in the 9th grade. Six groups (college physical science, college biological science, college nonbusiness, college business, noncollege science-technical, and noncollege nontechnical) were identified. He found a greater difference among the groups' needs means at Grade 9 than one year after high school, the same pattern observed for interests. He observed (p. 191) that a boy high on Sociability was more likely to leave physical science than a boy low on Sociability. Like interests, the motive variables appeared more predictive of current plans than of future ones. And the follow-up physical science and noncollege technical groups were lower on Sociability than were the other groups.

Using the same scheme of career plan organization, Cooley (1966b) studied the predictability of males' career plans as stated one year after high school from Grade 9 variables. The discriminant analyses yielded two discriminating functions based on the needs and interest variables. One function separated the college from the noncollege and the second separated the science-technical from the others. In both cases three needs variables made important contributions although interest variables carried more weight. In the first function Mature Personality and Self-Confidence scores were positively related to college-going and being in the physical science or biological science groups. In the second function Sociability was inversely related to being in a science or technical group. Thus, having a high interest in physical science, biological-medical science, and high scores on Mature Personality and Self-Confidence will direct the science-technical student toward college while a high Sociability score when coupled with the same interests and needs help predict technical career plans.

Since we have begun with Project TALENT, we will continue with H. S. Astin's (1967a, 1967b, 1968, 1970) studies of career development of boys and girls during the high school years. Her first study was based on 650 males who were first tested in 1960 and had taken the SIB as high school seniors in 1963. The objective was to predict senior year career plans from 9th-grade data. Her criterion groups were sciences, engineering, education-teaching, professions, other-no college degree required, business and management, and unclassified. In this study, she used only one needs modality—mature personality. The variable appeared as a heavily weighted predictor in the fourth of five discriminant functions observed. The Mature Personality Scale was useful in separating the professions from the science and teaching groups, a finding at variance with that of Cooley's.

In her subsequent study (H. S. Astin, 1970) of the predictability of 7,022 girls from the Project TALENT data bank, she used three "needs" variables, calling them temperament traits. In this case her subjects were those first tested as seniors, contacted again one year after high school, and responding to a survey five years after high school. The career plans of the subjects at the end of five years were placed in one of ten categories (natural sciences, professions, teaching, health fields, business, arts, social service/social sciences, office work, housewife, miscellaneous). The three temperament scales were Impulsivity, Sociability, and Mature Personality. Of the three only one, Mature Personality, entered the five discriminant functions. In two of five functions discriminating sciences from the other groups, Mature Personality was related to placement in the science group. However, it was more related to being in the professions group than the sciences group even though it was not heavily weighted in the functions. From the Project TALENT data we have seen that some needs are valuable in differentiating among vocational choices at different times in the subject's development. Using needs as an organizing variable, we turn to other work in the area.

Three research reports already reviewed (Eiduson, 1962 & Roe, 1953) and others (Harrison, Tomblen, & Jackson, 1955; Teevan, 1954) have used the Thematic Apperception Test or its offspring the Blacky Pictures Test, developed from Murray's (1938) personality theory based on a concept of needs. Murray's (1938) theory of personality focuses on the needs of the individual and their congruence to the resources of stimuli or press of the environment. The thesis is that an individual is motivated by needs to seek environments that can meet those needs. Thus needs are seen as motivating dispositions. Needs were identified as (p. 144): (a) n Abasement, (b) n Achievement, (c) n Affiliation, (d) n Aggression, (e) n Autonomy, (f) n Counteraction, (g) n Deference, (h) n Defendance, (i) n Dominance, (j) n Exhibition, (k) n Harm Avoidance, (l) n Inavoidance, (m) n Inviolacy, (n) n Nurturance, (o) n Order, (p) n Play, (q) n Rejection/n Seclusion, (r) n Sentience, (s) n Sex, (t) n Succorance, (u) n Superiority, and (v) n Inferiority. Eight other latent needs were identified along with four internal factors and 12 general traits. Analogous to the S-R model, each need is gratified or satiated by environmental stimuli. Although apparently no one has investigated the direct application of the theory to vocational development, its central concept of congruence between personality environment has been used by Holland (1966, 1968) in studying vocational choice and has been used in the study of vocational adjustment (Borgen, Weiss, Tinsley, Darvis & Lofquist, 1968a & b; Darvis, England & Lofquist, 1964; Darvis, Lofquist & Weiss, 1968; Weiss, Darvis, England & Lofquist, 1964, 1965). Also, Edwards(1959), until recently (Buros, 1972), provided a personality inventory which was designed to assess 15 of Murray's manifest needs and which has been used to predict college attendance patterns.

George and Marshall (1971) administered the Edwards Personal Preference

Schedule (EPPS) to 388 randomly-selected graduating high school seniors in 19 high schools in a large metropolitan area. The next fall they asked the subjects to report whether or not they were enrolled in college; 276 were and 112 were not. They controlled for differences in SES by dividing their subjects into two categories, high and low. They then used analysis of variance to determine the probability that the observed differences between the 15 manifest needs exhibited by the college and noncollege groups were due to chance. The students' mean scores on three scales were significantly higher than the nonstudents' — Achievement, Succorance, and Dominance. The nonstudents had higher mean scores on two scales: Abasement and Endurance. No interaction effects were observed and SES was related to only one scale—Autonomy. The high SES subjects had higher Autonomy scores than did the low SES subjects. Using Edwards' (1959, p. 11) definitions of the scales the students manifested needs to do one's best, be successful, accomplish tasks requiring skill and effort, be a recognized authority, have others provide help when in trouble, seek encouragement from others, receive affection from others, argue for one's point of view, be a leader in groups, make group decisions, settle arguments, and supervise and direct the actions of others. On the other hand, the students had lower manifest needs than the nonstudents along the following lines: to feel guilty after wrong-doing, to feel the need for punishment for wrong-doing, to feel better in giving in and avoiding a fight, to feel inferior to others in most respects, to keep at a job until it is finished, to work at a single job before taking on others, to stay up late working in order to get a job done, to put in long hours of work without distraction, and to avoid being interrupted while at work. As in other studies (Cooley & Lohnes, 1968; Williams, 1968), a scholastic achievement dimension differentiates the college bound from the noncollege bound.

Beyond the use of the EPPS to predict college attendance or nonattendance, no literature was found that related needs to expressed interests or vocational choice whether measured as a preference or aspiration. However, two reports identify needs of engineers. Izard (1960) administered the EPPS to 81 General Electric engineers with a variety of educational and geographic backgrounds. Their profiles were compared to those of 173 freshmen at Vanderbilt University who completed their first year in engineering, and to a random sample of 173 men in the College of Liberal Arts. The average profile of the engineers was compared to Edwards' male norm group by analysis of variance and t tests. He reported that the engineers had higher scores on Achievement, Deference, Order, Dominance, and Endurance and lower scores on Affiliation, Intraception, Succorance, Abasement, Nurturance, and Heterosexuality. When he compared the average profile for engineering students to liberal arts students, the engineers had higher scores on Order, Endurance, Intraception, and Affiliation and lower scores on Dominance and Expression. Because of the previously discussed attrition rate of beginning engineering students, the report of more scale differences for the engineers and the norm group is to be expected.

Gray (1963) compared the EPPS scale scores of 50 mechanical engineers, 50 CPAs, and 50 secondary school teachers. In this case the profiles of mechanical engineers and accountants did not differ, but the engineers' profile did differ from the secondary school teachers when subjected to t tests. The scales on which the engineers were higher were Achievement, Order, Dominance, and Endurance while they had lower scores on Affiliation, Intraception, Succorance, and Nurturance.

When engineering students were compared to male liberal arts students, the engineering students expressed greater manifest needs for Order (neat written work, making plans before initiating difficult tasks, having things organized, having meals organized, keeping letters and files according to a system), Affiliation (be loyal to friends, participate in friendly groups, make as many friends as possible, form strong attachments), Intraception (analyzed own motives, observe others, put own self in another's place, analyze behavior of others), and Endurance (keep at task until done, work at single job before starting another, stay up late working on job until completed) and less need for Dominance (argue for one's view, be leader, direct actions of others) and Aggression (attack contrary points of view, tell others what one thinks of them, become angry, blame others when things go wrong). When engineers were compared to the norm group of the instrument and secondary school teachers, they expressed greater manifest need for Achievement, Order, Dominance, and Endurance. Their needs for Affiliation, Intraception, Succorance, Abasement, and Nurturance were lower. Accountants expressed the same needs as engineers.

One other need theory, Maslow's (1970), has been used by Roe in her studies of scientists. Similar in dynamic aspects to Murray's, but without the emphasis on the environment, it is a theory of motivation. Maslow's is a hierarchial ordering of needs from the physiological needs of hunger and thirst through safety needs, belongingness and love needs and esteem needs to self-actualization. His thesis is that higher order needs cannot be attended to unless the lower order needs are first satiated. Aside from Roe's use of Maslow's concepts, apparently no one else has systematically investigated the usefulness of the framework in understanding vocational development.

One of the most researched psychodiagnostic instruments, The Minnesota Multiphasic Personality Inventory, has been used to study differences among students in various college majors, but rarely with a view toward scientists and never with a view toward technicians. Harder (1959) compared 204 profiles of juniors and seniors in education, engineering, and business at the University of Kansas. Only one of 12 clinical scales was found to differentiate engineers from business majors. The engineers had lower Hypomania (Scale 9) scores than did the education students—meaning they more frequently experienced mild degrees of manic excitement.

J. H. Clark (1953) found the Mf MMPI scale was the only one with power to discriminate among students with different majors. Physical science and mathematics majors, for example, had low mean scores on the scale. The scale was originally intended as a homosexuality scale, although it has never been satisfactorily validated for that purpose, and its interpretation is still the subject of some debate. Because of the few differences and its limited usefulness in discriminating among college majors, Clark cautioned against using the MMPI as a source for career counseling information. Two years later Sternberg (1955) used the MMPI, the Kuder Preference Record, and the Allport, Vernon, Lindzey Study of Values in an attempt to differentiate among college majors. In general the science group had trait patterns different from the English and music group, but the data do not lend themselves to prediction of individual students majoring in different fields.

Cattell's 16 PF Questionnaire (Cattell, Eber, & Tatsuoka, 1970) is an instrument probably most representative of the trait and factor theory of personality. In a recent publication he cites only one study (Cattell & Krug, 1967) which used his instrument to predict college major fields of interest. His own finding was that science specialization correlated .21 with Q 3 (self-control, persistence, foresight, conscientiousness, regard for etiquette and social reputation) and .25 with G (perservering, responsible, emotionally disciplined, consistently ordered, conscientious, concerned about morality) and -.42 with A (good natured, easy going, attentive to people, trustful, adaptable, warm-hearted). He summarizes (p. 235) "This tends to fit the traditional conception of the invicent, 'hard-headed researcher' in the physical or biological sciences as contrasted with the warm, exviant social scientist."

The California Psychological Inventory (Gough, 1960) has been used in a number of studies of vocational development. Tyler (1964) administered it to her subjects as they reached the senior year in high school after she had followed them for 12 years. The boys' scientist group scored higher on Psychological-Mindedness (observant, spontaneous, quick, perceptive, talkative, resourceful, and changeable; being verbally fluent; socially ascendant; rebellious toward rules, restrictions, and constraints) than the nonscience group. The boys' science group also scored lower on Dominance (aggressive, confident, persistent, and playful; persuasive and verbally fluent; self-reliant and independent; and having leadership and initiative potential) than the nonscience scale. The Dominance Scale sounds like the same-named scale in the EPPS reviewed earlier, where it was characteristic of engineers and engineering students.

Korn (1962) used the California Psychological Inventory to investigate the differences between engineering and physical science majors. The comparison revealed that physical science majors had higher scores on the following scales: Femininity (more feminine interests), Capacity for Status (ambitious, forceful), Achievement through Independence (mature, strong, dominant), and Flexibility (insightful, informal). Engineers had higher scores on the Sociability, Social Presence (clever, enthusiastic) and Communality (dependable, tactful) scales.

Goldschmid (1965) found virtually the same result when comparing seniors majoring in science to seniors majoring in the humanities. The science majors were found to be not assertive, spontaneous, or dominant (opposite of Tyler's 1964 findings).

Then, of course, we come to Cooley and Lohnes' (1968) work in *Predicting Development of Young Adults*. As will be remembered they used Lohnes' (1966a) MAP factors to predict future career plans of the TALENT male subjects. The criteria were college plans at the 12th grade (concurrent validity) and five years later (predictive validity). The three major discriminant functions observed were almost identical in functions. The first was a science-oriented scholasticism, the second a technical versus sociocultural function, and the third a business versus cultural function. The first function separated the physical and biological sciences (PhD level) from the sociocultural (MA level) group and the scholasticism motive variable had the highest weight among the MAP factors. The scale included items about grades, studying, curriculum, and courses, and reflected participation in academic life of school. Sociability (being with others, liking others, dating frequently) was positively related to technical plans and negatively to science plans in the first two functions. So it appears that scientists may be less socially-oriented than sociocultural groups, while technicians are more like the sociocultural groups.

Holland (1968), in a test of his own (1966) theory of vocational choice, used a variety of instruments in a longitudinal study of changes in vocational choice. His theory offers a structure of personality types and occupations which he briefly described:

> First we assume that we can characterize people by their resemblance to one or more personality types. The closer a person's resemblance to a particular type, the more likely it is he will exhibit traits and behaviors associated with that type. Second, we assume that the environments in which people live can be characterized by their resemblance to one or more model environments. Finally, we assume that the pairing of persons and environments leads to several outcomes that we can predict and understand from our knowledge of the personality types and environmental models. These outcomes include vocational choice, vocational stability and achievement, personal stability, creative performance, and susceptibility to influence (1966, p. 2).

There are six personality types for men: Realistic, Intellectual, Social, Conventional, Enterprising, and Artistic; and eight types for women: Intellectual, Social-Intellectual, Social-Conventional, Social-Enterprising, Social-Artistic, Conventional, Enterprising, and Artistic. The class of occupations and personalities with which this report is most concerned is those in the

Intellectual category which includes such occupations as biology, biochemistry, mathematics, and some which we have not considered previously such as dentistry, medicine, and military service.

Holland's Vocational Preference Inventory (1965) yields scale scores on each of his six dimensions of men's personality which he used to investigate the predictability of vocational choice classified into his six types and the predictability of occupational role preferences (1968). He found that the best predictor of vocational choice eight and twelve months later is an earlier vocational choice. However, when predicting choice for men, the Intellectual personality scale predicted an Intellectual vocational choice with 51.4% accuracy for men and 20.3% for women. When some stability was forced on the criteria by using a first and second vocational choice in the same category, the percentage of hits was 78.1% for men and 65.8% for women. So the Intellectual personality type is predictive of development toward an Intellectual career. The Intellectual personality type is defined as (Holland, 1966, p. 16) task-oriented, intraceptive, asocial, preferring to think through rather than act out problems, enjoying ambitious tasks, unconventional in attitudes and values, avoiding social situations, seeing himself as scholarly, intellectual, introverted, independent, submissive, original, and so on. Moreover, the Intellectual type prefers the vocational role of researcher.

Elton and Rose (1970) used Holland's typology as a way of classifying the freshman and senior year choices of 530 males at the University of Kentucky. In their study, the personality traits of their subjects were determined by the Omnibus Personality Inventory (OPI) (Center for the Study of Higher Education, 1962). This and Elton's earlier study (1967) mused five factor scores as traits which came from a factor analysis he conducted. The traits were named: Nonconformity, Scholarly Orientation, Nonauthoritarianism, Social Discomfort, and Masculine Role. Freshman choices were collected via The American College Testing Program's Student Profile Section and senior choices from graduation records. Once again, freshman choice was a better predictor of final choice than were predictions made from ability and personality traits. When looking for differences among occupational groups, Masculine Role, Scholarly Orientation, and high ability were related to expressing an Intellectual choice. The same three dimensions recur as important predictors of development toward Intellectual type careers whether looking at persisters or immigrants to the path. The order of importance changes though for immigrants where ability assumes primary importance over personality variables.

In the earlier study, Elton (1967) used the same independent variables as in the preceding study to determine the correlates of the vocational choices of the men who entered the University of Kentucky in 1965. In this study he classified the career choices in one of eight categories from The American College Testing Program's Student Profile Section and also used career role as a criterion. The results are virtually identical to those reported above. Those choosing scientific occupations had higher Masculine Role, Scholarly Orientation, and lower Tolerance and Autonomy. Those subjects who preferred researcher as a career role had high ability scores and high Scholarly-Orientation scores and low Tolerance and Autonomy scores.

In the three studies just reviewed level of career choice as an aspect of the criterion is neglected because of the focus on subjects enrolled in college. Although the differences are more useful from a counseling view than from a prescriptive view, differences in personality traits and ability levels are evident.

Self-Concept

Rogers' personality theory of the phenomenological self (see Hall & Lindzey, 1957; Pervin, 1970) has been applied to vocational development by Super and his colleagues (Super et al., 1963). The theory is similar to needs theory in its emphasis on the environmental effects, but it places more emphasis on cognitive attributes. Next to trait and factor it is the most-used theory in counseling and research on vocational development. Essentially, the individual's self-concept is his view of himself, either real or ideal, in terms of skills, abilities, interests, needs, etc., as learned from interaction with his environment. For example, our review of stimuli and their influence on vocational choice can be classified under this theory. The importance of parents, school, reference groups, and the like give the student the opportunity to proceed through various development stages. The potential scientist or technician implements such a self-concept by moving toward a career in science or technology. In this case, the self-concept seems to be formed early in the fantasy or tentative stages and solidifies during the exploration stage. This hypothesis is raised because of the observed lack of significant attraction to a science oriented career path from a nonscientific career path during the high school or college years. In any event, only one study of self-concept of scientists or future scientists was found.

O'Hara (1967) used multiple point biserial correlation procedures on 979 boys in Grades 9-12 to determine the relationship between self-concept and the choice of science or nonscience careers. The data consisted of Differential Aptitude Test Scores (Bennett, Seashore, Wesman, 1966): Kuder Preference Record-Vocational (Kuder, 1948); an altered version of the Allport, Vernon, Lindzey Study of Values; and the Work Values Inventory (Super, 1957). The measurement of self-concept was a nine-point self-rating on each scale of attributes measured. When predicting group membership, the multiple Rs for test scores by grade were: Grade 9, .5238; Grade 10, .4803; Grade 11, .4186; and Grade 12, .5987. When the self-ratings were added the resulting Rs were: Grade 9, .5565; Grade 10, .5755; Grade 11, .5749; and Grade 12, .6947; with a significant F for addition each time. In actual prediction his percentage of correct classification ranged from 84% to 76%, with the highest percentage coming at Grade 12. Based on statistical consideration then, self-concepts of subjects help predict career choice.

In general it is safe to conclude that as yet, differences in personality traits have not been demonstrated to be powerful correlates of the development of scientists. The two personality traits that seem to consistently differentiate those in science-technology paths from others are called Sociability and Scholarly Orientation, the latter being more characteristic of those choosing high level careers. Scientists tend to be asocial and scholarly. The concept of a mature personality, i. e., understands self, self-confident, planful, responsible, and self-controlling seems to be related to choosing a high level occupation, and there is some evidence that it is related to movement toward the sciences.

The attributes of future scientists reviewed in this chapter speak to the findings of O'Hara (1967); not only are future scientists typically bright with high achievement in the sciences and mathematics and high interests in the sciences, but they also see themselves as possessing all those traits.

Chapter IV

SYNTHESIS

In organizing this chapter, several approaches were considered. The first possibility was to organize it around a specific theoretical formulation like that of Super et al. (1963) with major sections for each stage in vocational development. Another was to organize it around general maturation periods from childhood through preadolescence and adolescence to postadolescence. Each approach had its advantages as well as disadvantages. For example, the problems in fitting the research into Super's stages, or Ginzberg's (Ginzberg et al., 1951) or Miller and Form's (1951) structures were two fold. First, the stages of development are defined by the properties of the expression of choice (vocational maturity, Super & Overstreet, 1960; Crites, 1971). Since those properties are only recently being explored (Crites, 1971; Westbrook & Parry-Hill, in press) and since the properties are not usually revealed in the research reviewed, the classification task would have been difficult, calling for inferences by the reviewer. Furthermore, the boundaries of the stages are not definitively established (see Crites, 1969, pp. 179-198).

The scheme used is a compromise between Super's stages and the structure of our educational system. The educational structure was used as the basic system due to our observation that the subjects of almost all the studies reviewed were classified by either age or grade when the criterion assessment was made, not in terms of their vocational maturity. The approach is not a new one; Cooley and Lohnes (1968) used a similar one in constructing their career development tree. Tiedeman and O'Hara (1963) have used a similar but more sophisticated framework, and others whose work is not reviewed in this report have used similar approaches.

This chapter then is divided into three major sections: the early school years, high school years, and collegiate years.

The Early School Years: Grades 1-8

The early school years encompass what Ginzberg et al. (1951) call the fantasy stage and what Super (1957) calls the growth stage, and they encroach on the tentative and exploratory stages of development. It is the period of time when the child first experiences formal education and perhaps enlarges his social contacts by the exposure to more peers. It is a period in which expressions of career choice or interest are more likely to be fantasy-oriented choices than reality-oriented choices. The family constitutes his primary reference group, and his cognitive and personality development is proceeding at a rapid rate.

In reality, it must be concluded that little is now known about the effects of the environment and personal attributes on vocational development during this period. The number of studies concentrating on parental-child relationships in relation to early development of interest in science are numerous owing to the work of Roe (1953) and Roe and Siegelman (1964). Yet only limited information is available for predicting development from one decision point to another.

Nature of Vocational Choice as a Criterion

Expressions of vocational choice during this period move from fantasy to exploratory. Since most are not reality-oriented, little work has been done on predicting these expressions of vocational choice. The main contributions to the knowledge of vocational development of scientists during this period have come from Roe (1957b; Roe & Siegelman, 1964), Eiduson (1962), and Cooley (1963a). In each case the determination of criteria was made after the subjects had progressed at least to high school (Cooley, 1963a) and in some cases to an entry occupation and beyond (Eiduson, 1962; Roe, 1957b). It is a reasonable expectation that high school curriculum choice (Sherman & Dole, 1961) be used as an immediate criterion in the study of early determinants of vocational choice toward the sciences for those fields in which the level of the entry occupation requires a baccalaureate or advance degree. In those fields, primarily technical in nature, where the entry occupation does not require a 4-year degree, such a criterion may be just as appropriate, although the intermediate criterion of college-attending cannot be predicted with certainty from the high school curriculum alone (Claudy, 1971; Hilton, 1971; Schoenfeldt, 1966).

Even in the area of level of aspiration, little has been done in the way of studying the characteristics of various criteria. For example, the observations of levels of fantasy choices may predict future, more stable, or vocationally mature expressions as might other groupings of vocational choice. Using the most gross two-category system, for example, Tyler (1964) and Roe (1957a & b) have found a thing-person dimension of interests. Precisely how early such a distinction can be made has not been determined. If early distinction is made, as Cooley and Lohnes posit and as Roe and her colleagues and others have attempted to demonstrate, it may be the first stage in the development of interest in the sciences.

In any event, three kinds of criteria of choice have been used in studies included in this section: expressed choice after the period as a preference and as a probability statement, and actual occupational field.

Environmental Press—Macro Systems

A major difficulty in organizing this information is determining how the influence of social class begins, ends, and peaks in a developmental framework. Is it when the subject is very young and his reference group is the family, or is it when his primary reference group is his peers during adolescence? At first glance one might say early, yet SES is also a sociopsychological phenomena, meaning that in part it determines to which peer group one has access (Coleman, 1969). Since such a determination or distinction was not made in the research reviewed, we will assume as a guiding principle the age of the subject at the time the SES index of the family was determined This also allows us to consider SES in its various interpretations as discussed earlier. For that reason only one study can be included. Cooley (1963a & b) tried to discriminate among three classifications of subjects using characteristics of the home environment. The criterion was membership in a prospective science pool, a college nonscience group, or noncollege technical group as of Grade 9. The predictor variables were collected when the subject was in the fifth grade. "One important finding here is that variables of socioeconomic status (father's education, mother's education, father's occupational level, mother's working or not, and a home scale, i.e., books, etc., in home) are not related to membership in three criterion groups. Family status appears not to be involved at this early stage of development, not even when college or not is a consideration." Because his sample was restricted to high ability males and 9th-grade statements of career plans, his results should be interpreted with caution. However, the observation is an intriguing one and should be investigated in a larger study.

No research was found that reported the influence of geographical origin, community of residence, or religion on vocational development in the early school years.

Two studies were found that focused on the differences in aspiration levels of elementary school children with differing racial backgrounds. Holloway and Berreman (1959) found that the occupational aspirations of white middle class youth were higher than those of black youth, and that the educational aspirations of the two groups were not identical (Ausubel & Ausubel, 1963; Boyd, 1952; Deutsch, 1960). Hindeland (1970) reexamined the issue in a study of elementary school students, and expanded the sample to include Mexican-American offspring. The largest proportion of black students expressed college aspirations (92%) while 85% of the white students and 71% of the Mexican-American students made the same response. When asked about occupational aspirations, whites held the highest (60% stated white collar/professional) with black next 53% followed by Mexican-Americans (48%); the differences were not significant. We find perceptions of parental aspirations at this level to be predictive of educational aspirations of young children and that the levels of educational aspiration differ by race as early as the 4th, 5th, and 6th grades. What influence these early levels of aspiration have on later development has not been established, but they would certainly appear important.

Environmental Press—Micro Systems

The micro system of family has been the object of concentrated study by Roe (1957a) and others investigating the efficacy of her theory of early determinants of interest. Roe (1957a) theorized from her earlier studies (1946, 1949a, 1949b, 1950, 1951a, 1951b, 1952a, 1952b, 1953, 1956) that the direction of vocational development (i.e., field) was a function of parent-child relationships. She hypothesized that the child whose parents were either overprotective or overdemanding would most likely enter service, business, general arts, or entertainment fields. Those from an accepting relationship would likely enter social science fields, while those from avoidance relationships would enter science fields. Subsequent research by Green and Parker (1965); Grigg (1959); Hagen (1960); Switzer, Grigg, Miller, and Young (1962); and Utton (1962) failed to yield substantial support for Roe's theory. However, Roe and Siegelman (1964) point out in an extension of the theory, the methodological limitations of the studies are such that they do not definitively negate the entire theoretical structure.

In this later study Roe and Siegelman (1964) asked college students to recall their parent-child relations during the period of time before they were 12 years. In general, the results were not supportive of the specific dimensions of the theory of vocational choice; however, they did report evidence that early parent-child experiences partially accounted for later life orientation toward people or not toward people. Thus early experience may place boundaries on the directions of vocational development, but those boundaries can be broken by later experiences or subsequently modified by other experiences which direct them toward specific occupations.

Parental influences on children can take the form of more explicit kinds of pressures such as educational and vocational expectations and aspirations for their offspring. Cooley (1963a) found that among 20 environmental factors assessed when his male subjects were fifth graders, only parental expectation and aspiration levels were related to planning or not planning a career in science in the 9th grade. At the same time manifest interests, liking for school work, having a science hobby, coming from a broken home, expressions of father's reinforcement of a career in science, and SES were not. Consequently, we see the first evidence that parental expectations and aspirations may be more related to vocational development during the early school years than a variety of other factors.

Because of the established generalization that peer groups do not play a major role in development until adolescence, there is apparently no research related to their influence on early science career development.

The role of the elementary school and stimuli within the school have not been investigated in the study of the development of scientists. It would appear that the importance of the early school experiences on self-concept formation would be of particular concern (Labenne & Green, 1969; Purkey, 1970) to vocational psychologists. It is the time when self-perceptions which ultimately result in self-concept systems are being tested, thereby having major implications for later vocational development. The role of the elementary school in vocational development needs to be examined.

In general, for the early school years, parent-child relationships have been the one major concern of vocational psychology. Parent-child relationships as they were hypothesized by Roe (1957a; Roe & Siegelman, 1964) have been the subject of some study but with largely negative results. Perhaps a reformulation and better definitions of vocational development criteria during the early school years would be beneficial. The work of sociologists on the relationship between race and level of aspiration needs to be explored further, as does the role of early aspiration in later development toward the sciences and technology. At later periods of development, we see that sex is the most powerful predictor of vocational choice. The role of the family and schools in the early development of sex role has been firmly established and yet largely ignored by vocational psychologists other than Tyler (1964). Overall, it must be said that the study of environmental influences on early vocational development have yet to be adequately explored.

Response—Cognitive Development

It would seem plausible that early development or manifested aptitudes and general scholastic ability would be related to vocational development toward or away from science. For example, one would not expect the child having difficulty with science and math to express an interest in a scientific or technical career. However, if theory is correct and such expressions are only becoming reality-oriented (Super, 1957) perhaps we should expect frequent "unrealistic" choices of science.

Cooley (1963a & b) overcame the criteria problem by using 9th-grade career plans as a way of classifying students in a Potential Science Pool (PSP), College Non Science pool (CNS), or Non-College Technical pool (NCT). As 5th graders he gave his male subjects the Sequential Test of Educational Progress (STEP) (1957) Math, Science, and Reading, and as 6th graders the Otis Quick-Scoring Mental Ability Test (Otis, 1937), and as 8th graders the STEP Math and Science tests again. The tests were not predictive of group membership even though as early as the 5th grade there were significant differences on the test scores.

The interaction of SES, general academic abilities, and race has been found to have a major effect on personal development during the early school years (Deutsch, Katz, & Jensen, 1968). Although there is only limited evidence (Tyler, 1964) that these factors affect vocational development, their influence appears sizable.

Response—Interests

The early influences of family on interest development have been documented by Tyler (1964). As early as the 4th grade her subjects showed differentiation of interests on a masculine-feminine dimension which then differentiated between subjects who later showed interest or disinterest in science. These early interests probably have more relevance to setting the stage of later interest development within those two general domains than they do to specific interest formation. Roe (1957b) hypothesized that scientific interests emerged in the form of hobbies and the like at an early age. Eiduson's (1962) and Cooley's (1963a) studies seem to refute the hypothesis, with the latter being more applicable to the early school years. Furthermore, since Cooley's subjects were high ability male students, sex role and ability were controlled. If it is true, as we have hypothesized, that sex role formation begins before and during the early school years, and the development of children becomes vocationally-oriented in the latter part of this period, it seems reasonable to conclude that the masculine-feminine (Cooley, 1963a; Tyler, 1964) or toward people-away from people (Roe, 1957a) dimensions serve to establish limits on the future directionality as well as level of vocational interests and therefore choice. The relative importance of the two dichotomous dimensions and their relationship need to be investigated in depth both in terms of direction and level of future expressions of choice.

Reliance on manifest interests during this early period is almost mandatory because of the lack of a fully-developed interest inventory. Yet the relationship between such things as subject preferences and later interest in science careers has not been established.

Response—Personality

Depending upon one's theoretical orientation, the early school years are more or less important in personality development. If one uses psychoanalytic theory (Bordin, Nachmann, & Segal, 1963; Kubie, 1954) as a basis for understanding behavior, the basic structure of the personality is considered to be already formed by the early school years. Thus the environment should play a decreasingly important role in personality development. However, the usefulness of psychoanalytic concepts in understanding vocational development during the early school years and particularly in relation to scientific careers has not been determined.

The self-concept theories emphasize the importance of later periods in vocational development. Thus, no studies of the relationship of self-concept percepts at this stage to science interests have been uncovered.

To date Cooley (1963a & b) has been the only one to attempt to predict future science-nonscience career plans by a "trait" personality inventory, and he was unable to do so. Thus, there is some evidence that early personality differences do not distinguish among children in ways related to movement toward a career in science.

In summary, we see that a good deal of attention has been paid to the influence of parent-child relationships on vocational development and less to SES, school, ability, and personality effects, and that all efforts have had largely negative results. It would appear that some of the most valuable research in this area is related to theories of personality development. Perhaps constellations of self-perceptions predict future self-concepts which ultimately are related to vocational choice. Judging from the payoff of research in this area, the potential value of studying scientific and technical development can only be found in terms of studying the establishment of broad limits (things-people, masculine-feminine) rather than on future development and factors which subsequently support or break the limits.

The High School Years: Grades 9-12

The high school years have traditionally been considered crucial in vocational development. It is during the high school years that the student first may specialize in an educational program, that his peers take on new importance as reference groups (Hadley & Levy, 1962), and that psychosexual behavior patterns emerge for girls and begin for boys. It is also the period when differences in vocational development begin to appear.

Nature of Vocational Choice during the High School Years

It is during adolescence that exploratory behavior becomes directed to the point that tentative choices appear. The number of career choices of a student decreases during this period, but theoretically choices begin to increase in specificity (Crites, 1969, pp. 157-169). It is a time during which vocational maturity (Crites, 1971; Super & Overstreet, 1960) begins to acquire some meaning; that is, the adolescent begins to recognize the importance of work in the lifespan of man and becomes aware of the necessity of planning for his future career. Concern tends to focus on reality, making this one of the critical periods of vocational development.

It is at the beginning of this period that the pupil faces his first decision with an aura of irreversability (Ginzberg, et al., 1951; Tiedeman & O'Hara, 1963; Super et al., 1963); future changes in direction and level become difficult.

Unless the student enters the college-preparatory program, his options for change in direction are substantially narrowed. However, Cooley's (1963a), Hilton's (1971), and TALENT results (Flanagan & Cooley, 1966; Flanagan et al., 1964, 1971) suggest that the decisions may not be as irreversible as they once were. The erosion of clearly defined curriculum program in high school, movement to open door colleges and universities, and the differences in states' reliance on the secondary school or community college to provide technical education, makes the high school program less reliable as a criteria for development toward science.

Expressions of career choice during the high school years tend to be highly unstable (H. S. Astin, 1967b, 1968; Flanagan, 1966; Watley, 1968). However, the instability is substantially reduced when choices are grouped by field to introduce some structure (H. S. Astin, 1967a & b; Cooley, 1966a & b; Holland, 1968; Roe, 1957a & b) according to similarities of content, worker traits, or other elements. In general, when many fields are used, the stability rate for career choices over four years is around 16% identical choices for men and 26% for women and is even lower for those choosing science (Flanagan, 1966) although that stability rate for women also tends to be higher than for men. When a four-fold (Cooley, 1963a) or six-fold classification scheme (Cooley, 1966b) is used a 40-45% stability rate is found over the high school years. One of the reasons for the lower stability rates for the sciences is the tendency for an out-migration pattern (H. S. Astin, 1967b) throughout both high school and college. More students abandon plans for natural and physical science careers then embrace them after expressing other goals.

Environmental Press—Macro Systems

The influences of social class, geographic region, religion, and racial and ethnic background on vocational development during the high school years have received considerable attention.

Social class. The relationship between social class and college-attendance patterns is well-established (Claudy, 1971; Schoenfeldt, 1966; Trent & Medsker, 1968); the question is whether or not there are differences among the backgrounds of those moving toward different scientific and technical careers.

It is during the high school years that SES emerges as a variable of importance. The early studies of scientists (Super & Bachrach, 1957) concluded that, in general, natural scientists and physical scientists were favored with upper middle class backgrounds. The conclusion is not surprising because the middle class is the modal SES classification and college attendance is related to SES patterns. In fact there is a growing body of evidence that SES is more related to college attendance patterns than it is to particular vocational choices. Those studies which concentrated on subjects identified as potential scientists (Bull, 1954; MacCurdy, 1954, 1956; Norman, 1965) either found no differences in SES between those moving toward science or did not report comparison data (Daniels, 1966). Dole and Sherman (1964) are an exception, but they failed to report differences between their two college-bound groups, emphasizing differences between college-bound students and all others. In general they concentrated on college-bound students for whom SES is a powerful predictor of group membership (Williams, 1968; Cooley, 1963a & b). Cooley (1963 a & b) found that an 8th-grade assessment of SES was a better predictor of movement toward science as an expressed career plan at the 12th grade than it was as an 11th-grade predictor of group membership in a simple two-category criteria of college science or non-science five years later.

Of course, SES has more meaning and implications than a simple class structure. Classes differ in values, attitudes, and expectations, as well as in characteristic peer group associations. Consequently in studying the impact of SES on vocational development, father's occupational level or parental educational level probably is not an optimum index of SES, because it obscures the effects of inheritability of occupations (Werts, 1966b), parental expectations and aspirations for their offspring (Cooley 1963a & b), and the influence of peers and parents (Herriott, 1963).

Community. No research was found which focused on the impact of religion or geographic influences on the vocational development of scientists and technicians during the high school years. Therefore we move to the influence of urban-rural backgrounds on educational plans, studied almost exclusively by sociologists (Burchinal, 1961; Grigg & Middleton, 1960; Haller & Sewell, 1957; Middleton & Grigg, 1959; Sewell, 1964; Sewell, Haller & Straus, 1957; Sewell & Orienstein, 1965; A. Wilson, 1959; Youmans, 1956). In terms of vocational development, their results are somewhat less than definitive because of the tendency to use level of educational or occupational aspiration as the criteria with no reference to fields. It is clear that high school students from rural backgrounds and small towns have lower aspiration levels, both educational and occupational, than do their peers from urban areas. When ability, SES, and sex are held constant, the differences decrease markedly, but the pattern still holds (Sewell & Orienstein, 1965). Precisely how the size of hometown or its census designation affects aspiration level is hypothesized to be related to job opportunities in the hometown and perhaps differences in values placed on education by adults. Yet, if high aspiration level is a necessary, although not sufficient, precondition to embarking on an educational career in preparation for the sciences, size of hometown may be an initial limiting factor. The same may be true for those who enter technical occupations, although they may have an initially lower level of aspiration.

Racial and ethnic background. As we indicated earlier, the impact of racial background on the development of young children has been substantiated (Deutsch, Katz, & Jensen, 1968), but not independent of SES and sex. Because minorities are overrepresented in the lower SES classes, the effects of SES on their general development operate to exclude them from the sciences and other advanced fields. If race had no effect on development beyond limiting entry to college, but SES did, we would expect minorities to be overrepresented in a paraprofessional or technical occupations to a similar degree that they are overrepresented in the lower SES categories. In contrast, had there been no racial barriers, minorities would enter college-preparatory programs in high school, science-preparatory programs in college, and science occupations in a proportion to their representation in the institutions and other programs within them.

Studies of racial differences have, like studies of SES influences, focused on level of aspiration and level of expectation (Antonovsky, 1967; Antonovsky & Lerner, 1959; Ausubel & Ausubel, 1963; Gist & Bennett, 1963; Hindelang, 1970; C. Johnson, 1969; Lott & Lott, 1963; Sprey, 1962; Stephensen, 1957; Weiner & Murray, 1963; Wylie, 1963; Uzel, 1961--see Prohansky & Newton, 1968 for a review of some of the preceding studies and others). The results are best characterized as "mixed."

In almost every case SES is controlled to isolate the influence of race although the use of head of household's educational level or occupational level as a common SES index is probably unsatisfactory here, too, because of the social psychological phenomena of reference groups and social structure. For example, being a black engineer and living in a ghetto implies a different status than being a black or white engineer and living in the suburbs. Almost every study cited reports that aspirations are higher than expectations regardless of race, but with greater differences for minority students. Investigation of the interaction between sex and level of aspiration or expectation has produced some different results. For example, Pallone, Rickard, and Hurley (1969) report differences by sex within race as does Sprey (1962), but they report opposite orders of effects. In the latter case, girls had higher aspirations than boys, while in the former the reverse was true. Moreover, in the former there were interaction effects of community and SES. Others like Stephensen (1957) and Gist and Bennett (1963) found no differences in aspiration levels by race, while Hindelang (1970) reported differences in educational expectations with blacks highest, whites second, and Mexican-American lowest. Due to differences in methodologies and factors studies we can only conclude that SES, sex, and community may or may not interact with race to effect vocational development, but their effects on development toward or away from the sciences are probably related to college attendance or non-attendance, as are the effects of other macro social systems during the high school years.

Environmental Press—Micro Systems

As has been pointed out before, the effects of the macro systems can be understood only in terms of the micro systems which give the macro systems their structure.

The family and peers. During the adolescent period the family declines in importance as a reference group; yet its importance in vocational development during the high school years still is considerable. Because many of the pertinent studies on parental influence on vocational development were primarily designed to compare their influence to peer influence, we have combined the two in this chapter.

The thrust of the research in this area has been guided by self-concept or ego personality theory. It has concentrated primarily on the influence of the expectations and aspirations of significant people in the student's phenomenological world on his career plans. Further, it has concentrated on the perceived expectations and aspirations although actual press is sometimes assessed.

In establishing a general level of aspiration or expectation several kinds of factors seem to operate during the high school years, some of which make independent contributions which are additive in effect (Herriott, 1963; Rehberg & Westby, 1967; Simpson, 1962). There is evidence that social class bounds can be overcome when parental aspiration levels for the child are supported by the reference peer group; when parents and peer reference group are in conflict, parental aspirations have greater effects (Simpson, 1962). Moreover, depending on social class there seems to be a differential effect between which parent is influential (Ellis & Lane, 1963); the lower the SES the more likely the mother will be the influencing parent. Others (Bordua, 1960; Harris, 1970; Hollister, 1969; Krays, 1964) have determined that the influence of peers on levels of aspiration is considerable, and Rehberg and Westby (1967) have shown that parents' aspirations and peers' aspirations make independent contributions. Another use of peers is as a comparative group rather than a reference group. Herriott's (1963) impressive results have shown the independence of the effects of parents' and peers' expectations and the view the student has of his abilities as compared to the abilities of his peers. Parental expectations have been found to be related to both the SES backgrounds of mothers and job satisfaction expressed by fathers (Cohen, 1965). If the father is dissatisfied with his job and if the mother came from a higher SES than is characteristic of the family, the more likely is the level of aspiration of the offspring to be high. Moreover the kind of aspiration held by the parents, whether for a professional career or financial success, may direct the gifted student toward or away from science, respectively (Brandwein, 1955).

Some studies of the inheritability of science occupations (Bull, 1954; Daniels, 1966) have found a small but distinct relationship between having a father employed in science or a technical occupation and the offspring's interest in a science career. The early ages of the subjects may mean the observed relationship is a phenomenological one where closeness to the occupation is more related to its frequency of expression as a goal than to an actual mature choice. Yet, in a series of studies of college freshmen, Werts (1966b, 1968) found evidence that father's occupation is related to offspring's expressed vocational career plans. If those expressing career plans that match father's occupation are left out of the analysis of SES effects, it is clear that for men lower SES is related to choosing a career in engineering and chemistry among the sciences and higher SES leads to a career in the humanities and professions. Differences among the backgrounds of those choosing physical and natural sciences are not as marked, but these students tended to come from the middle class. Women expressing science career goals were equally distributed among SES levels after father's occupation was controlled.

Thus a variety of conditions seem to affect vocational development in terms of the level of educational and occupational aspirations and expectations.

There is less evidence of parental and peer influence on the choice of science or technology as a career. The same phenomena of parental expectations and aspirations which operate on level of aspiration also appear to operate to establish field objectives. Cooley (1963a) found that the most powerful environmental predictor of orientation toward science, technology, or some other field was parental expectation. Indeed it outweighed indexes of SES, manifest interests, and other environmental characteristics in his discriminant analysis in predicting 12th-grade plans based on 8th-grade assessment variables. Yet the usefulness of the SES data in separating the four groups (prospective scientist pool, college nonscience, noncollege technical, noncollege nontechnical) is apparent and the major discriminating function worked to separate the college bound from the other two groups. The same kinds of results were observed when using 11th-grade predictive data to place subjects in the same criterion groups five years later. Father's and mother's expectations were more functional in separating the college-attending groups from the nonattending groups, and again expectations of parents outweighed SES indexes in the function.

In general, it seems safe to conclude that during the high school years, like SES, parental expectations and aspirations operate to influence college attending or not attending and therefore serve to separate those developing toward science or technology only to the degree the training requirements differ.

School. There are various stimuli within the school that have potential for influencing career development. They include teachers, counselors, school curriculum programs, and peers. The high school is probably the first encounter the student has with a required narrowing or specialization of activities, although the reduction in breadth is fairly small at first. Academic competition increases probably as a partial function of the realization by some students of the relationship between achievement and breadth of future opportunities. It is a time when the student can compare his abilities with those of peers with similar goals, and evaluate his relative chance of success. The importance of this opportunity has been demonstrated by Herriott (1963).

There is some evidence that courses influence students' future development, but the effect appears small (Dole & Sherman, 1964). When looking specifically at the relationship between the kinds of courses taken and development toward a science or technology career, taking a foreign language is more predictive of a college-noncollege group membership and, when combined with taking math, is more predictive of a technical orientation (Cooley, 1963a); science-technology groups tend to take less foreign languages and more math than their peers. Whether or not previous experiences in similar programs preceded the high school curriculum pattern is uncertain.

When the size of the school is used as a measure of the magnitude and frequencies of potential stimuli, two kinds of results have been observed. Among PhDs in the sciences, size of high school is positively related to entry into the physical sciences (L. Harmon, 1961). When professions are included in the study, no major differences are found among the various scientific fields according to the size of the high school (H. S. Astin, 1967a); yet size of high school was predictive of entry into the professions.

Teachers are cited frequently as influencing students' choice of high school science programs (Dole & Sherman, 1964), choice of major subject area in college (Ellis & Lane, 1963), and level of aspiration (Day, 1966; Herriott, 1963; Rehberg & Westby, 1967); but no direct evidence points to significant influence of teachers in directing students toward science careers during high school.

There is some evidence (H. S. Astin, 1967a) that the high school curriculum also gives students the opportunity to explore their interests, abilities, and achievement motivation level. It is clear that students' expressions of career choice show marked change during the high school years. Cooley (1963a) found that male students in a college-preparatory curriculum do not differ in their patterns of science courses taken, but he and H. S. Astin (1967b) have shown that attrition from science paths during the school years is considerable. The relationship between nonachievement experiences in courses and orientation to science and technology is not fully-documented, but the evidence suggests a major curriculum effect particularly in discouraging students from pursuing science education programs (Morrison, 1970).

In summary, the influences of parents, peers, and school all seem to contribute independently to level of career plans but not to specific fields. Moreover, the effects of the micro social system of family, peers, and school can overcome social class bounds and may operate independently of religion, racial and ethnic backgrounds, community and geographic region, and SES to establish aspiration or expectation levels. Yet, in terms of vocational development, the major identifiable impact during the high school years is a level consideration.

Response-Cognitive Development

There has been considerable research on cognitive development and its relationship to vocational development during the high school period. In this section we review those studies that look at the general academic ability levels and specific aptitudes and their relationship to the choice of a career in science or technology.

General academic ability. The conception of general academic ability as general problem solving or symbolic manipulative ability would lead to the hypothesis that persons with higher levels of general ability would have an easier time achieving in relatively difficult areas and perhaps be challenged by the disciplines requiring higher abilities. Whether or not they choose such disciplines over other comparable levels of occupational aspiration and whether general ability differentiates by level of career choice is the focus of this section.

The relationship between general academic ability and vocational development has been investigated with less intensity and frequency than one might suspect. The problem has been the establishment of adequate criteria and methodology. Although general academic ability tests have norms for different populations we have concentrated on predictive studies. The problem is the dearth of such studies owing perhaps to the old cliche that as long as an individual has the minimum level of intelligence for entry into the occupation, increasing amounts of intelligence will not guarantee success. The other problem is that predictive validities are generally established based on success rather than on entry because the criterion variables are only available for those completing a training or education sequence. Now however, with the increasing use of discriminant analysis, more work will be done in the entry area where the criterion is available for all subjects. What has been done in observing the effects of intelligence on development toward science will be summarized below.

General academic ability does appear to be related to choosing a science career objective during high school or shortly thereafter. By high school, general ability is much more related to career plans toward science and technology than it was during the junior high school years (Cooley, 1963a). In Cooley's (1963a) study of 8th-grade predictors of 12th-grade career plans he found that the college-attending groups had higher scores on one-score and multiscore tests than noncollege attenders and a discriminant function showed that the science group had higher general ability than did the college nonscience group. Moreover, the noncollege technical group had higher scores than the noncollege nontechnical group. So general ability operated to differentiate the groups within levels of career goals. What appears to be happening then is that as students progress through high school, differences among abilities and aptitudes tend to be accentuated. Super et al. (1963) would consider this evidence of reality testing, while Holland (1966) would see students as seeking congruence between personality type and environmental type. Regardless of the explanation, sorting by ability level does seem to occur, and for the first time we see a directional effect (Cooley, 1963a) within levels of career development as well as a general level effect (Cooley, 1963a; Lohnes & McIntire, 1967).

Achievement—proficiency. Two kinds of variables typically have been used to reflect achievement: (a) standardized tests and (b) high school grades or rank in class. It is reasonable to assume that one will not pursue a career path in which gathering evidence suggests he cannot succeed. Because the relationship between achievement indexes and intelligence indexes is very high, it would be surprising if we did not find achievement related to vocational development. We find that class rank discriminates between college- and noncollege-bound groups but not particularly well between science-technology and other orientations. So rank in class gives clues to level kinds of plans.

Three knowledge trait areas were assessed in Project TALENT: English, mathematics, and information which are defined as (Lohnes, 1966b, p. 78) "ability to recall and apply information in a subject-matter area. Knowledges may depend more on specific learnings and less on innate characteristics of the central nervous, afferent, and efferent systems than do aptitudes." Once again they find both a level effect (Flanagan, 1966; Schoenfeldt, 1966) and a direction effect (also found by Mierziva, 1961) with their achievement tests dominant on the level dimension and aptitudes dominant on the directional dimension, although high achievement in math and science and low achievement in sports information and literature information helps to separate the science-technology groups from the others.

Aptitudes. Again we rely on Project TALENT as the source of studies of the influence of aptitudes on development during the high school years. Cooley (1966b) found that mechanical reasoning as an aptitude separates science-technology oriented students from others when other achievement variables are allowed to operate. H. S. Astin (1967a) found different dimensions, but this was probably due to differences in the way in which the criterion groups were defined. However, when achievement information is available, aptitudes generally do not offer much weight in predicting level of career plans during the high school years.

We have seen that during the high school years the macro social systems appear to have more importance in establishing level of career plans, while response variables have two effects, a level effect (see Taubman & Wales, 1972, for a more complete review) and a directional effect. Furthermore, the directional effects are on what seems to be a business/humanistic-science continuum. The directional distinctions are not unlike those proposed by Roe (1957b) and Roe and Siegelman (1964), as well as Tyler (1964) who used high science interest or rejection of science interest as a criterion for 12th-grade boys. However, the patterns of directionality were not evidenced by the Primary Mental Abilities or the Iowa Test of Educational Development tests but by an interest inventory. Another striking observation can be made at this point. Every study cited in the response section with the exception of Tyler's (1964) has concentrated on boys, a pattern that will continue, but become more differentiated as we move into college and post-college years.

If the criteria are different, as in Astin's study that separated the engineering groups from the physical sciences and grouped all noncollege subjects together, different results are observed, but the restricted nature of the sample makes generalization difficult. Moreover, if we assume that expressed interests are at least as predictive as inventoried interests, using more than six or eight occupational classifications greatly reduces predictability (Flanagan, 1966).

Response-Interests

The same kinds of directional and level patterns were observed in the study of interests during the high school years. The establishment of level of career choice has been adequately demonstrated over the years (Cooley, 1963a, 1966b; Lohnes, 1966a; O'Hara & Tiedeman, 1963; Tiedeman & Bryant, 1965). There is also some agreement in the kinds of interest factors found regardless of whether the interests are assessed by inventories (H. S. Astin, 1967 a & b; Cooley, 1963a; Tyler, 1964; O'Hara & Tiedeman, 1963), manifest interests (Cooley, 1963a), tested interests (Cooley, 1966b), or expressed interests (Cooley, 1966b) as long as there is some fairly small number of criterion groups patterned like Cole and Hanson's (1971) structure of interests.

What kinds of interests patterns separate the students by level? It appears a science interest (Cooley, 1963a; Lohnes, 1966a; Tyler, 1964) and high scholastic interests (Cooley & Lohnes, 1968; Williams, 1968) coupled with low interest in mechanical and outdoor (Cooley, 1964; Cooley & Lohnes, 1968; Lohnes, 1966a) and literature (Tyler, 1964) characterize the high-level groups. The combination of a high science and high mechanical interest with low literary and social service interests separates the science-technical groups from the others (Cooley, 1963a; Lohnes, 1966a) and in particular within the levels.

Now that two categories of responses have been discussed the question naturally arises about their interaction effects on vocational development during the high school years. As expected the effects are not contradictory (H. S. Astin, 1967a; Cooley, 1963a, 1966b; O'Hara & Tiedeman, 1959; Tiedeman & Bryant, 1954; Tyler, 1964). For example, when Tyler used science interest as a criteria, general ability and achievement tests differentiate directional tendencies. Yet the addition of aptitude and interest measures to intelligence and achievement tests differentiates both by direction and level and improves prediction. Moreover, as Cooley (1966b) demonstrated, ability measures are better predictors of future activities than are interest measures, while the latter are better of the two in predicting current plans. From this and Tiedeman and O'Hara's work (1963) we can conclude that the high school years do indeed affect vocational development but primarily in a two-level four- or six-category directional matrix. General ability, achievement, and interests are related to level, while general ability, aptitudes, and interests are predictive of direction.

Response—Personality

The prediction of vocational development toward the sciences from particular personality views has been somewhat limited since most research in the area has been in a dynamic rather than specific outcome context. The usefulness of personality traits as predictors of vocational development during the high school years has been investigated by four major studies.

Cooley (1963a) reported that the Guilford-Zimmerman Temperament Scales given at the 11th grade was not particularly useful in predicting 12th-grade plans. There were some significant differences in scale scores of different criterion groups but membership could not be predicted with impressive accuracy. Using the High School Personality Questionnaire and considering trends across age groups, he found an early introversion tendency for his science-technology groups although a 9th-grade administration of the instrument did not offer sufficient predictive power to correctly classify subjects by their 12th-grade plans.

Tyler (1964) obtained similar results in her attempt to concurrently predict personality traits from the California Personality Inventory and to postdict them with the Edwards Personal Preference Schedule and the Guess Who. The TALENT 1-year follow-up studies (Flanagan & Cooley, 1966) were not much more successful in predicting from their need-motive factors to career plans one year after high school.

Two factors were related to level considerations (Mature Personality, Self-Confidence) while only Sociability was negatively related to a scientific or technical orientation one year after high school (Cooley, 1966b). This personality dimension was close to those identified in his earlier study, except in this case it made a substantial contribution to the discriminant analysis.

The usefulness of a specific science-nonscience dichotomy as a criterion and the interaction of interest, aptitudes, and self-concept were investigated by O'Hara (1967). He concluded that the self-concept as he defined it adds to the predictability of the direction of vocational choice. In fact, when self-ratings (concept measures) were added to multiple prediction equations, aptitudes dropped out of the equations suggesting that self-understandings of aptitudes were more important in predicting science career choice than were actual aptitude measures.

Earlier we suggested that social forces or environmental press seemed to be more related to the establishment of levels of choice than to specificity of choice. During the high school years this seems to be particularly true for the macro social systems. But with the micro systems, the evidence appears to support the view that they also impinge on the direction of choice, particularly for science (Crites, 1971; Holland, in press; Super et al., 1963; Tiedeman & O'Hara, 1963).

Summary

During the high school years we are increasingly able to predict the vocational development of adolescents in both level of career choice and direction. The increase in predictability of 12th-grade or 13th-grade plans must be attributed in large part to the sorting process that occurs over the four- or five-year period. Since most of the sorting for a scientific or technical career is "out" (H. S. Astin, 1967b; Cooley, 1963a, 1966b; Flanagan, 1966), it appears that scientific occupations have some general attractive aspect to youth and that the reality-testing opportunities provided by the school experience are substantial. Moreover, since ability measures are more predictive of change than are interest measures (Cooley, 1966b; Cooley & Lohnes, 1968), and the changes seem to be within two levels, the early establishment of levels seems to constrain changes from scientific to technical careers and certainly severely inhibits the reverse.

What else do we know about the career development of scientists and technicians during the high school years except that they tend to be a residual group? We know that the scientists tend to be a great deal like nonscience college-bound students and technologists tend to be a good deal like noncollege-bound groups. Yet, the scientists and technologists tend to be much alike in some respects. The predictive validities based on expressed goals as early as the 9th grade are about as predictive of future development as are all the psychological testing that can be mustered (Cooley, 1966b). All of which leads to the conclusion that we can partially identify factors—and it takes more than a one-dimensional measurement space to identify them—that affect development during the high school years However, the dynamic aspects of the interaction of these factors is the greatest need in future research. Combining the efforts of those concerned with outcomes in terms of what Holland (in press) calls structure, and those concerned with what he calls process-theorizing and research will advance our knowledge immensely. Perhaps the combining will be accomplished by the emerging interest in decision-making approaches (M. Katz, 1966; Kroll et al., 1970; Tiedeman & O'Hara, 1963). The observation that theory building has outstripped the validation of those that exist is certainly supported by our review.

Probably the most fruitful kind of research conducted during the high school years is that which looks at the interaction effects of school-related stimuli, personal attributes, and the role of those who are significant in the perceptual field of the students. It seems clear that SES, sex, tested ability, interests, and some personality traits bear on vocational development and are useful predictors of direction and levels of plans. Whether one uses a multidimensional measurement space or a simple typology, their value to counseling is apparent. However, an understanding of precisely how environmental and personal factors affect development will come only through basic and intervention research tied to what we know from current research on decision-making and the dimension of personal attributes.

It is clear that the environmental-personal interactions which influence vocational development are exceedingly complex, and that clear understanding of the process cannot be unraveled simply by looking at one part of the interaction. Rather, it will take a broad spectrum view of the process which includes both environmental and personal characteristics as independent variables.

The College Years: 1-4 Years after High School

The first few years after high school graduation is witness to a continued sifting or what Super et al., (1963) call floundering and trial (A. W. Astin & Panos, 1969; Cooley, 1963a, 1966b, 1967; Cooley & Lohnes, 1968; Davis, 1964b, 1965; Elton & Rose, 1970; Flanagan et al., 1971) which, for the most part, is orderly (Cooley & Lohnes, 1968; Elton & Rose, 1970; Holland & Whitney, 1968). Although expressed career plans are at least equal in predictive validity (Elton, 1967; Richards, 1971a; Stahmann, 1971; Whitney, 1969) to attribute measurement, vocational development continues in a dramatic fashion. It is a time when the sciences at least continue to lose members; we have only limited data on what happens to the paraprofessional, technically-oriented students. It is also a time when sex role differences continue and perhaps are enhanced.

The tendency for researchers to concentrate on the collegiate years and the career development of collegians is a legacy of a number of factors including the value society has placed on college and the availability of subjects for observation.

Environmental Press—Macro Social Systems

The relationship between macro systems and vocational development during the collegiate years is puzzling. If the effects of social class are relatively permanent and established during preceding years, they should be apparent during the collegiate years. If, as we have hypothesized earlier, the major effects of macro systems are primarily level effects, no important differences in SES, geographic region, race and ethnic background, or religion should be observed within the college-level population.

Social class. Studies both of differences among and differences within fields have been conducted on the relationship between social class and the career development of scientists. Depending on how career plans are grouped into criterion categories, as well as how social class is measured, SES is found either to be related or unrelated to career plans. For example, when level of father's occupation is used as the SES index and engineering is combined with other sciences, no differences are found (Cooley, 1963a); yet when put in a category of their own, engineers tend to have lower SES backgrounds than other scientists (A. W. Astin & Panos, 1969). Yet when parental levels of education are used as SES indexes, there is no difference among fields even when engineering is treated as a separate field. The impact of SES on differences among fields can probably be best estimated by controlling for the inheritability of occupations. Father's occupation appears to have a definite impact on offspring's direction of career development (Cooley, 1963a; Werts, 1966b, 1968), particularly at the upper levels of SES since father's influence on vocational development appears inversely related to SES (Ellis & Lane, 1963; Prohansky & Newton, 1968).

One way to partially control for the inheritability of father's occupation might be to use parental education levels as SES indexes or use composite indexes of SES (H. S. Astin, 1970; A. W. Astin & Panos, 1969; Davis, 1964b, 1965; Werts, 1966b). The results are mixed probably because of differences in the composition of criterion groups. There does seem to be a hierarchial arrangement among fields with the professions and humanities having the highest SES background and with education and engineering having the lowest SES backgrounds. Within the sciences, engineering tends to be overchosen by those from the lower social classes. Otherwise there is little agreement on major differences within the science fields unless agriculture is considered a science (Harmon, 1965).

In those studies that compared the value of social class as a predictor of development, thereby defining the impact of social class background on science paths, SES was not the most important variable (H. S. Astin, 1967; Cooley, 1963a). Consequently, although differences in backgrounds are observable (Harmon, 1965; Schwartz, 1965) and it may be useful in predicting among fields, SES does not seem to be an important variable in predicting the direction of career development among the sciences. The evidence seems to be that after high school SES is still primarily a level factor.

Geographical origins. The collegiate years are the first period during which geographic influences on vocational development toward the sciences have been studied. Studies did not use subjects' home state as the index of geographic origins. Rather, the locale of the institution from which the student graduated was used. To the degree that the origin index is appropriate for the sciences, the studies provide some reliable findings.

In contrast, with earlier studies (Knapp & Goodrich, 1952; Visher, 1948), it seems clear that students from the northeast or eastern part of the United States provide the pool from which scientists are drawn (A. W. Astin, 1963b; A. W. Astin, Panos, & Creager, 1967; L. R. Harmon, 1965). This may be related to the East's industrial concentration plus its density of high prestige universities devoted to research. Thus the attractiveness of the sciences is enhanced by direct observation of their value, work, and prestige.

Religion. Like geographic influence, the impact of religion has been investigated only at the collegiate level. In four studies (A. W. Astin & Panos, 1969; Cooley, 1963a; Davis, 1964b, 1965; Snelling & Boruch, 1972) there seemed to be a pattern that those with Jewish backgrounds did not enter the sciences and if they did, tended toward biology or chemistry. Those from Catholic or Protestant backgrounds tended to be equally represented in the sciences and when compared to other fields, Protestants were overrepresented. Again the relationship established is probably more related to father's occupation than the effects of strong religious backgrounds preventing or promoting science interests.

Racial and ethnic background. The level of social class and social barriers have guaranteed that minority students be underrepresented in college and therefore in all the upper levels of the occupational structure of this country. The question of racial influences on career development of the minorities has been a matter of broad social concern related to equal opportunity. The evidence we found in our review does not support the popular stereotype of blacks avoiding the sciences. Whether one looks at the career plans of graduates of predominantly black colleges (Fichter, undated) or probable field of study upon college entry (Bayer & Boruch, 1969), the only science field in which blacks are underrepresented within their general underrepresentation in higher education is in engineering. The contrast with the SES finding that engineering is overchosen by lower SES students, is striking. A complete reversal of the SES-related pattern of choice within the sciences is evident if one assumes those blacks in higher education come from low SES backgrounds (Bayer & Boruch, 1969). The major differences in career plans by race, in addition to engineering, are in education and business. Controlling for sex, blacks are overrepresented in education, underrepresented in business, and underrepresented in engineering (Fichter, undated). However, when looking at plans for graduate school, once again a level constraint is imposed within the sciences and among other fields, but its strength seems to be less. The effect may be due more to SES than to race, as is pointed out by Hager and Elton (1971) who investigated differences in science interest between white and black males at one college.

Environmental Press—Micro Social Systems

The importance of the family, peers, and college or technical school on the vocational development of scientists and technicians is summarized in this section.

The family. Like the influences of the macro social systems, the influences of micro systems are more likely to be residual than primary. Their presence is hard to deny from the time of high school graduation and entry into college (Ellis & Lane, 1963; Smith, 1963) to sometime later (Cooley, 1963a; Werts, 1966b; Werts & Watley, 1970). In the collegiate years there does seem to be a clarification of the role of parental expectations and the relationship between father's occupation and offspring's choice of a career in science. If the father has a science-related job, the more likely the student will express a science-related career plan (Cooley, 1963a; Werts, 1968) during the collegiate years. The expectations of parents continue to be predictive of career plans (Cooley, 1963a) in science, although we do not know if the nature of the expectation (Brandwein, 1955) might be more predictive.

The studies of parental identification and interest development leave a number of hypotheses (Crites, 1962; Heilbrun, 1969; Henderson, 1958; Hollender, 1972; Steimel, 1960; Steimel & Suziedelis, 1963; L. H. Stewart, 1959; White, 1959) in need of investigation. Some differences were observed in the dominance of and the identification with either parent and entry into one of the sciences. The carryover into the collegiate years, and the strength of the relationship to career patterns has not yet been determined. The relationship between parental influence and movement toward the sciences and technology during the collegiate years seems more potent, than, when investigating the inheritability of science-related careers.

Peers. The importance of peer groups has been investigated with some success. It appears that peers have at least a marginal amount of influence in attracting students into the sciences (R. D. Brown, 1966) and perhaps a major influence in their persistence toward science (Davis, 1964b) as a career goal. Students were attracted to the sciences by either having friends in the sciences or because they considered themselves better students than their peers. The importance of peers as a comparison group or reference group during high school years seems to continue into the collegiate years.

College or technical school. Perhaps one of the most studied areas in higher education has been the impact of college on students (Feldman & Newcomb, 1969). Moreover, many of the studies were directed toward identifying a school's productivity of scientists, so a wealth of findings were reported in the review.

What began as a study of the productivity of scientists by institutions (Knapp & Goodrich, 1952; Knapp & Greenbaum, 1953), quickly shifted focus through a series of studies (A. W. Astin, 1963b; A. W. Astin, 1961; A. W. Astin & Holland, 1961; A. W. Astin & Panos, 1969; Davis, 1964a, 1965; Holland, 1957; H. A. Korn, 1968; Thistlethwaite, 1959, 1960, 1966) by those at the National Merit Scholarship Commission and later other agencies and institutions, and concentrated on the impact of college on the vocational development of students.

The focus of the studies of college impact was on some differential effects after college student input was controlled. The nature of the campus climate was viewed as the primary force acting on the vocational development of the students. Some differential effects were identified, yet their impact appeared to be relatively minor when compared to the personal attributes and plans the students brought with them to college.

Changes within fields of study during the collegiate years (Flanagan & Cooley, 1966; Holland & Nichols, 1964) are clearly orderly (Holland, 1968; Holland & Whitney, 1968; H. A. Korn, 1968), yet their numbers are very large, suggesting a hypothesis of major college effects, particularly from course content (Holland, 1968) on vocational development during this period. But the degree of specificity in the changes within fields presents methodological problems in dealing with observations of minute details.

Aside from Holland and Nichols (1964) and Davis (1964b) surprisingly little research has been conducted on the influence of faculty on the choice of scientific careers. The popular notion of the influence of a great teacher during the undergraduate career has not been documented and may be a misconception.

The influence of macro and micro systems on the vocational development of scientists has been the object of only limited study except for the impact of college. Nevertheless, judging from what has been reviewed, it may well be that during the collegiate years macro social systems have marginal influence, and micro systems have little additional influence on future scientists. Whether the same would be true for technicians is open to study.

Response Variables

Research on postsecondary students has concentrated largely on predicting success in postsecondary education and psychodiagnosis of student personality. Nevertheless, some work has been done on predicting vocational development from the measurement of student attributes. Once again, technicians are an overlooked group.

General academic ability. The academic achievement of students during the postsecondary years has not been extensively studied because of the massive evidence that general academic ability is a useful predictor of success in college. There is some growing evidence that general academic ability plays an ordering role in vocational choice (Cooley & Lohnes, 1968); that is, students who leave the sciences during the collegiate years tend to have lower scores on tests of general academic ability so that as seniors, the remaining group is more homogeneous in ability (Cole, Wilson, & Tiedeman, 1964; Elton & Rose, 1970; Holland, 1968). When career plans of college freshmen (Elton, 1967) or seniors (Elton & Rose, 1970) are described in a two-dimensional space, the ACT composite score of the seniors is the best predictor. During the freshman year, the composite is less important than variables such as personality traits in predicting career choice although it has the heaviest weight in the occupational role (highest weight is for researcher). As seniors, the composite carries the greatest weight in comparison to personality traits in predicting persistence in and change to science career paths.

Achievement. Similar to the findings on general ability, achievement indexes such as rank-in-class are predictive of a science direction but not of a technical-nontechnical orientation during the collegiate years (Cooley, 1963a). However the weight of the achievement variable suggests that it is a better predictor of science group membership than is aptitude or other standardized achievement measures of mathematics or science, although both make additional contributions to the prediction equation.

In other uses of standardized achievement tests (H. S. Astin, 1970; Cass, 1959; Cooley, 1967; Holland & Nichols, 1964; Richards, 1971), the same kinds of results are observed for both women and men. That is, future scientists tend to have higher achievement records in mathematics than do other students, and technical students tend to perform better than nontechnical students, but not as well as all college science students (Cooley, 1963a, 1967; Cooley & Lohnes, 1968).

Aptitudes. The answer to whether college students in different majors or students with different plans possess different aptitudes depends on whether or not measures of achievement, personality, and interest are included in the study, and the predictive methodology employed.

Fortunately we now have better means than scale-by-scale comparisons (Millholland & Womer, 1965) of aptitude test scores to help answer the question. In Cooley's early (1963a) work, aptitudes were not particularly powerful predictors of science career choice even though college science students had higher spatial, logical, numerical, and verbal aptitudes than his other three groups. Richards (1971b) found low-to-moderate positive relationships between Project TALENT cognitive tests and career choice improved by adding noncognitive variables to the equation, but his number of fields was quite large. Cooley and Lohnes (1968) found that a score "mathematics" representing the sum of a number of similar achievement tests was a powerful predictor of change or persistence in career plan. And H. S. Astin (1968, 1970) found the same kind of TALENT score was useful in predicting science career choices by women. In all cases the central aptitude for scientists was mathematics knowledge which tended to separate the scientist from the nonscientists among all subjects, and separate the technical fields from the sociocultural fields by grouping the sciences and technical fields together at the opposite end of the continuum from the professional-sociocultural fields.

It is fairly clear that direction of career path can be reliably predicted from either achievement, general ability, or aptitude tests. The predictability is enhanced if a separate mathematics aptitude or achievement score is available and the groups are fairly heterogeneous on general academic ability (Watley, 1969b). Consequently, we can conclude that in terms of ability, the sciences, except for engineering perhaps, (Holland & Nichols, 1964) tend to retain students who during the collegiate years both tend to see themselves as being better students than their peers (Davis, 1964b) and are better at symbolic manipulation of abstract constructs.

Interests. During the collegiate years, interests as measured by inventories tend to be fairly stable (Campbell, 1971). However, for those students leaving the sciences, the modal reason cited (Holland & Nichols, 1964) seems to be a lack of interest in the course content. Even during the collegiate years a high interest in scholasticism is characteristic of college-attending students although those actually pursuing a science path exhibit greater interest in scholastic activities than do their cohorts (Cooley & Lohnes, 1968). However when differentiating between technical and sociocultural career paths, both the science and technical students have high science interests, while the technical students are clearly a less scholastically-able group. Because of the lack of comparable instrumentation among studies, it is difficult to identify other differences.

Expressed or manifest interests are certainly reliable predictors of future career paths (H. S. Astin, 1970; A. W. Astin & Panos, 1969; Berdie, 1960a & b; Dolliver, 1969; Stahmann, 1971; Whitney, 1969) depending upon how the criterion is determined. If many paths are used (Richards, 1971a), the relationship decreases and varies widely among paths. Expressions of interest in science are typically less reliable predictors than expressions of interest in other fields. As far as could be determined, none of the TALENT measured interests contributed to the prediction of a science or technology career path except that literary information scale (H.S. Astin, 1970) for women. In this case, as in Cooley's (1963a) report using the Kuder with men, the lower the literary interest score for a man or woman, the less likely he will go into science. However, it is also clear that the pattern of interests is more important than a particular interest score (Cooley & Lohnes, 1968).

It seems that interests are powerful predictors of future development; but since they are better predictors of current goals than future goals, they are clearly subject to change. Are interests antecedents to choosing career paths? The question is a difficult one to answer, but the definition of interests as likes and dislikes leads to the conclusion that they are learned attributes. The early emergence of science-oriented scholasticism (Cooley & Lohnes, 1968), and the outmigration pattern for science paths suggest two hypotheses. First, the formation of an early interest in science seems related to ending up in the upper levels of our occupational structure although not necessarily science. And second, even if science interests develop during the collegiate years, the cost of changing from a nonscience to a science path is so high that it acts as an effective barrier to movement.

Personality. In the third chapter two major approaches to the study of the relationship between personality structure and dynamics were reviewed, of which only one, trait and factor theory, clearly has been applied to the study of vocational development during the collegiate years.

In some cases the traits were called need modalities (H. S. Astin, 1970; Cooley & Lohnes, 1968; Flanagan et al., 1971; George & Marshall, 1971); in other cases they represent collections of traits (Elton & Rose, 1970; Folson, 1969; Holland, 1968); and in other cases the traits have been derived from factor analysis or item analysis (Cattell & Krug, 1967; J. H. Clark, 1953; Cooley, 1963a; Elton & Rose, 1970; Goldschmidt, 1965; Harder, 1959; H. A. Korn, 1962; Norman & Redls, 1952; Sternberg, 1955).

In general, univariate trait and factor approaches to differentiating within the sciences and among other fields is not particularly productive, and observed differences on scale scores are not likely to be reliable. It is likely that when using the unifactor approach physicists will look like chemists, mathematicians, etc. The most deviant group typically is engineers. One of the consistent findings was that science groups tended to be low on dominance traits and sociability. In fact, Cooley (1963a) and Cooley and Lohnes (1968) found that besides having lower scholastic interests and lower ability and achievement patterns, technically-oriented students could be separated from the science groups because the latter were less social.

When multivariate procedures are used, it seems clear that ability and interests both play a greater role in predicting change and persistence in career paths (Cooley, 1963a; Cooley & Lohnes, 1968; Elton & Rose, 1970). Consequently personality patterns, as defined by trait and factor approaches, do not seem to have any overwhelming effect on the choice of science and technology as careers.

Post-Baccalaureate Years

Beginning with the establishment of the National Science Foundation in 1950, the Congress has authorized substantial amounts of funds to support graduate training in the sciences. The National Aeronautics and Space Administration; the Atomic Energy Commission; Veterans Administration; Department of Defense; Department of Health, Education, and Welfare; Department of the Interior and other agencies also support graduate study in the range of sciences included in this review. Mathematics, physical science, biological science, and engineering combined have been better supported in terms of the number of graduate students aided than have the social sciences, education, and arts and humanities (Froomkin, 1970), although the distribution pattern has evened out in recent years. It is important to consider the impact of this massive support on the career development of scientists and technicians. Two questions are relevant. One is whether the availability of funds encourages students to seek graduate training. The second is whether or not students are attracted to particular fields because of available monies for continuing their education.

Froomkin (1970) undertook the most extensive review of the effects of graduate student support through federal agencies that was found. He concluded:

> It does not appear that the extent of financial support available in a specific academic speciality has induced more students to choose a graduate career in that speciality. The percentage increase in PhDs granted between 1961 and 1967 bears very little relationship to the percentage of PhD students supported [p. 70].

Froomkin continues:

> There is some concern about the possible development of an over-supply of persons with advanced degrees, especially in the physical sciences. Yet our studies have indicated that a recommendation to cut the support for students in these disciplines would probably not reduce the number of graduate students [p. 73].

Froomkin points out that some support for his conclusions comes from a study of graduate students by Davis (1962). In the fall of 1958 Davis surveyed 3,000 randomly chosen graduate students in the natural sciences, social sciences and humanities in 25 institutions. The purpose of his survey was to determine the sources of financial support of graduate students and their impact on educational progress. The subjects were followed for one year when their progress was again assessed.

The results led Davis to conclude that in general graduate students tend not to be in debt, tend not to worry about financial support, find support through a variety of sources, and their degree of financial pressure or worry was not predictive of withdrawing from school. Since over 70% of his respondents received a stipend of some kind and 41% received half or more of their total income from stipends, some questions still remain. For example, what portion of the 70% would not have entered graduate school had they not received a stipend? What portion of the 70% would have entered another speciality if a stipend had not been given through their original speciality? Davis' data do not give definitive answers to these questions. The answers are probably related to the relationship between fields where money is available. For example, if all support for mathematics were transferred to physics, it is hard to believe this would not have any effect, such as producing more physics graduate students with a mathematics background. Whether undergraduate physics students who had not contemplated graduate study in physics would be attracted is a matter of speculation.

In fact, as Davis subsequently found (1964a), the availability of stipend support does seem to play a role in the decision of undergraduates to pursue or not pursue an advance degree. It certainly seems to mediate against entrance if there is no support for the student. However, unavailability of aid was reported by students to be less of an obstacle than the internal factors of motivation. That is, the motivation to pursue an advanced degree must be present before the issue of availability of stipends becomes an influencing factor.

The influence of economic considerations on vocational development recently has been studied by some like Vander Well (1970) but has been absent from larger studies like Project TALENT and Folger, Astin and Bayer's (1970) work largely because of the lack of faith in economic theories of career choice (Crites, 1969). Much has happened in the area of federal support for education since Davis' (1962, 1964a & b, 1965) studies (Froomkin, 1970; Rivlin, 1961) and perhaps it would be of benefit if vocational psychologists were to renew their interest in the area.

Conclusions and Recommendations for Future Research

In this section we will attempt to organize our views and reach some conclusions based on what research indicates about choosing a career path during the educational years toward physics, chemistry, astronomy, mathematical sciences, environmental sciences, life sciences, social sciences, and engineering at the professional and paraprofessional levels.

Conclusions and Discussion

Almost all research included in the two review chapters comes from aspect of vocational psychology Holland (in press) characterizes as concerned with the structure of the world of work and *prediction* of career choice and educational and career path movement. Little has been reviewed from those he sees as concentrating on the *process* of development. The latter school has been primarily concerned with understanding the process of development and the quality of the outcomes but not with specific career choices. Both groups have made significant contributions to the study of vocational development; we see each complementing the other. However, there does seem to be a need for merging the thrusts if we are to adequately describe the effects of personal and environmental variables on specific career paths such as science and technology.

We find that for the most part the research related to our area of concern was easily classified as either stimulus or response oriented. The interaction effects between stimuli and responses are rarely studied much less understood. Sociologists tend to concentrate on intelligence level and social class or parental expectations while psychologists tend to overlook environmental factors in their work choosing to concentrate on response factors. The major need in future research seems to be to identify environmental stimuli that interact with personal variables to produce movement along one career path or another. The thrust would be analogous to emphasis on aptitude-treatment-interaction effects in learning theory (Cronbach & Snow, 1969). The essence of the approach is that certain environmental stimuli and combinations thereof, interact in different ways with different combinations of personal attributes to produce different consequences. The growing evidence of these interaction effects from those researchers using discriminant analysis techniques in predicting career development (H. S. Astin, 1967a & b, 1968, 1970; Cooley, 1963a, 1966b, 1967; Cooley & Lohnes, 1968; Elton, 1967; Elton & Rose, 1970; Hilton, 1971; and others) seems sufficient to warrant more attention to identifying these effects. To date, those studies that have looked at interaction effects seem to suffer from limitations in operational definitions of either the response or stimulus variables or have been primarily concerned with the interactions of response variables on development. Had those who have and are studying the *process* of development reported their results in terms of specific paths and had sociologists been concerned with direction as well as level of career and educational aspiration, more would be known about the interaction effects.

Because the majority of research reviewed in this report is predictive in nature, the conclusions are organized in a predictive model. A discussion of the criteria is presented, followed by a discussion of predictors in terms of their degree of relationship and influence.

The Criterion—Career Path toward the Sciences

Different kinds of criteria were used in different studies according to the time span under observation and the explicit purpose of the study. During the early school years prior to entry into high school the criteria ranged from levels of educational and occupational aspirations, school subject preferences, the high school curriculum selected, expressions of vocational choice, and combinations of the preceding. During the high school years criteria of science interests, high school curriculum, career plans, and combinations were used. During the collegiate years college major, training program enrolled in, graduate school plans, occupational role desired, and expressions of career plans were used as criteria. In some cases the criteria were unidimensional such as college attendance or nonattendance and in other cases the criteria included considerations of occupational role, level of career choice which was primarily dichotomized as requiring college preparation or not, and direction of career choice. The inconsistencies in the operational definitions of the criteria from one study to another are one of the underlying reasons for the contradictory findings reported in the review chapters.

One of the difficulties that has been encountered by vocational psychologists over the years has been the search for an adequate description of the structure of career choices. There is a general agreement that Roe's (1957a) level and groups of occupations is one of the most complete descriptions and Holland's typology (1966) has also been found to be a useful framework (Elton & Rose, 1970; Holland, 1968; Holland & Whitney, 1968). It is clear that a simple enumeration of career choices without regard to the relationships among them has an immense amount of instability as late as the collegiate years (Flanagan, 1966; Richards, 1971c). Moreover the very nature of expressions of career choice during the early school years makes expressions of career choice, preference, or aspiration tenuous criteria by themselves. Nevertheless, the research which was reviewed does lead to some conclusions about the dimensions of career paths.

During the early school years a one dimensional array seems sufficient to characterize vocational development. The one dimension of masculine-feminine or thing-person reappears in a number of studies of children's interests or personal orientations prior to entry into high school. But even three specific career paths as Cooley (1963a) used in his study of the junior high school years did not prove to be predictable, perhaps as a consequence of criterion assessment. Therefore, it seems desirable that expressions of career choice, preference, or aspiration during the early years be made a secondary aspect of criteria determination. Perhaps the most fruitful kinds of criteria to be studied are those which might be called conditions for future path differentiation. In this regard such things as constellations of self-precepts, interests in subjects in school, attitudes about science and scientists, and masculine-feminine or people-thing dimensions of interest all offer possibilities as criteria. The kinds of research needed are similar to those that define stages or periods of development, something that is not clearly understood in the early school years.

During the high school years at least two dimensions of career paths are observable. One is a bi-level dimension of college or noncollege orientation, and the other is a four- or six-category directional dimension. Categorizing expressions of career choice by the sex of the respondent is clearly necessary if sufficient stability is to be introduced to provide efficient prediction. When typologies like Holland's (1966) have been used to classify career paths, they have been very useful within high levels of choices although their usefulness across levels has not been as well established, it seems plausible that they would be appropriate for both high and low levels of career choice. Whether it is possible to make finer discriminations among the various levels of occupations like those defined by Roe (1957a) is not clear. The multivariate research consistently found that two levels of career choice during the high school years are easily discernible and perhaps more importantly, are the best predicted criteria. That is, we are much better equipped and able to predict level of choice than we are direction of choice. But again the consistency of the observation of a level dimension of choice as the first discriminant function may be a function of the fact that only two levels were included as part of the criteria of choice. Had more levels been incorporated, perhaps a directional function would have emerged as the primary one.

It is clear that relying on the career plans of high school subjects as the primary property in defining the criteria introduces natural instability. In fact, we have seen that expressed choices of physical and natural science and technical careers with the exception of engineering are even less stable than expressions of career plans toward other fields. This instability calls attention to the need for some study of at least two other dimensions. The first dimension is the maturity (Crites, 1971; Super & Overstreet, 1960; Westbrook & Parry-Hill, in press) of the choice and the second is the study of occupational role (Elton, 1967; Holland, 1968) as a part of a career choice.

Because of the legitimate concern of counselors in being able to help a student determine his probability of being at a certain stage of training sometime in the future, there apparently has been little attention paid to the quality of the expressed career choice which is being predicted. Perhaps the introduction of such a qualitative consideration will provide more insight into those who radically change their career paths, say from physics to social service.

Sometime during the late high school years and perhaps with some finality during the collegiate years, occupational role seems to play a part in the choice of a career. Precisely what that part is has yet to be determined but it seems to be important. For example, it may be that the out migration from the physical, biological, and applied sciences can be accounted for by the realization by students that the role of researcher is present in other disciplines or fields of work. The same phenomena might account for the dearth of "recruits" to the physical, biological, and applied sciences and technology during the collegiate years when coupled with the highly structured nature of preparation for the careers. Students who might be otherwise attracted to the physical sciences, find a research role in their present field of study. Furthermore, perhaps it is the variety of roles available in all high level career fields that introduces the little stability there is in expressions of career plans. Precisely when role considerations become a part of career development is unclear. There is some evidence that by the fifth year after high school when role is introduced as a part of the criteria, in this case via inference from the educational aspirations of the subjects, three functions are necessary to predict the career choice (Cooley & Lohnes, 1968) whether one is focusing on persistence or change in career paths.

In summary, then we conclude that:

1. During the early school years, a one dimension thing-person, masculine-feminine continuum of personal orientation or interests is observable. The evidence is not at all clear but suggests that students who will move toward physics, chemistry, astronomy, mathematical sciences and engineering have an early thing orientation. Students with a person orientation are more likely to move toward the social sciences and perhaps the biological sciences.

2. During the high school years, a two-dimensional space is necessary to describe career paths. One dimension which consistently emerges as the primary or most predictable one is a college-other continuum and the second dimension has been termed a directional one from physical, biological science, technology to arts and humanities, business. Taken in combination these two dimensions mean that at least in terms of the response variables of abilities, interests, aptitudes, and personality, there are systematic differences in patterns of personal attributes of students on different paths.

3. During the collegiate or postsecondary school years, the career path space appears to be a three dimensional one in which role or amount of post-baccalaureate education received adds a new dimension to the space. Once again a two level dimension (advance degree—no post-secondary training) seems to be the primary one, the second and third are directional dimensions. The second is a technical, physical science, and engineering social science dimension and the third is a business-arts and humanities dimension.

The preceding three conclusions say something about how career paths seem to be structured. Now we can present some conclusions about what the literature suggests about movement along career paths toward the sciences.

4. Beginning in high school and continuing through college the physical,

biological, and engineering sciences have a net loss of career path members while the social sciences, education, and business have a net gain in career path members. The exact ranking of specific rates of loss and gain are not certain, but:

(a) Engineering appears to have the greatest out migration, but the highest proportions of students who persist in the path from one point to another (i.e., has the lowest in migration);

(b) the physical sciences and biological sciences have similar patterns of out migration with the biological sciences having a greater in migration than physics, chemistry, etc.

5. When two dimensions of career paths are used, one a college-non-college and the other four to six groupings of fields, about 42% of the students remain on the same path from one year to as many as five years later. When 25 or 30 paths are identified, an average of only about 20% of the students persist on one path between the 9th grade and college entry. The physical and natural sciences tend to be well below the average.

6. There is some evidence to suggest that the junior year in high school may be a crucial time in orienting students toward the physical or natural sciences (Flanagan, 1966; O'Hara, 1967). If students are not oriented in those directions by the 11th grade, the likelihood that they will change paths to the physical and natural sciences is remote. The sudden spurt in stability of choice rates between the 10th and 11th grades needs further investigation before the importance of the observations can be determined.

7. There is strong evidence that among very talented students engineering and physics paths have been declining in popularity during the past decades. Yet engineering remains the most popular career choice — about 20% — of 9th grade boys who are going on to college. By five years after high school only about 5% continue to state engineering as a goal. Similar patterns are observed for the physical sciences, but the biological sciences, social sciences, as well as the physical sciences do not have more than 2% of all the young men and women from college entry to four years later on any one of 31 specific paths.

8. During the collegiate years, there is a distinct pattern of movement within levels of career paths, but movement across levels from a collegiate level to a noncollegiate level appears to be a relatively low occurring pattern particularly for those beginning college on a science path. Those on the original physical science and engineering paths are most likely to change to social science or business paths if they change. Those on social science paths are most likely to change to business. Those on the biological science paths are most likely to change to a social science path. Thus, there is no large scale movement from engineering paths to paraprofession-

al technical paths. The differentiation of levels of career orientation during the high school years remains fairly stable during the collegiate years.

The Predictors

The objective of the review of research was to identify those environmental and personal factors which account for the persistence and changes in career paths that lead to the sciences. If this review did not include the social sciences, it would be easy to concentrate on two kinds of students—those who persist and those who leave the path sometime during the educational years. However, since the social sciences are included and since there is some movement onto physical and biological science paths, a third group the immigrants—can be identified.

Of course, timing becomes a part of movement along the paths. How long it takes for the subjects to get from one place to another, when the initial commitment is made to the path, and when changes are made are all of some importance in the process of development along career paths.

Ideally this section would organize what is known about external and internal factors affecting career development according to the strength of their influence. However, because studies of response variables tend not to include stimulus variables and vice versa the ordering can only be done for some of the factors. Moreover, level of career path or level of aspiration not only can be better predicted than direction, but some factors seem to be more related to level than direction of choice while other factors seem to be more related to the direction of choice within each of the two levels of college training and "other" paths.

In almost every study that has been reviewed, the independent variables being observed were found to make some contributions to the prediction of the criteria. The differences in designs, thrust of the studies, the criteria and the definitions of independent variables all act to inhibit the ability to order the variables according to their strength. So the following paragraphs represent an interpolation of what we think the literature suggests.

Level of career choice. Six factors stand out as being consistently related to level of career path selected whether level is defined as amount of education or prestige of the career choice.

SEX

Even though sex and sex role seem to play a greater role in determining direction of career choice than level of career choice, they do have a powerful level effect, particularly at the high school to college and college to graduate study transitions. A little over 50% of the males in high school graduating classes enter college within five years of graduation, while only 40% of the girls of the same cohort do. Even in those fields dominated by women, four to six times as many men hold advanced degrees in the field. However, in the physical sciences which have the lowest ratio of women to men, there are proportionately more women with PhDs than PhD women in the biological or social sciences.

GENERAL ACADEMIC ABILITY

General academic ability consistently emerges as an important predictor of level of career path. Where previous career choice is not a predictor, general academic ability clearly separates the college-oriented student from those pursuing other paths. Within levels of career paths there is a distinct hierarchy of levels of general ability associated with particular career paths with the physical sciences at the top in the college group and the technical students at the top in the noncollege group. However, the differences tend to be small across paths within levels making it extremely difficult to distinguish physicists from chemists from biologists, for example, in terms of general academic ability.

PARENTAL EXPECTATIONS

The third most powerful influence on level of career path is parental expectation. The literature suggests that parental expectations can overcome even social class barriers to mobility through education. The importance of parental expectations seems to be a function of social class in that the lower the social class background the more important that parents hold high expectations for the offspring if the children are to pursue a collegiate path. Moreover, the congruence between parental expectations, peer group influence, general ability level and so forth seems to be very important. In fact as counselors know, parental expectations in some cases are more influential in level of career path than other factors including the student's own preferences.

SOCIAL CLASS

The fourth factor that has an influence on level of career path is social class. It is clear that social origin is moderately related to attending or not attending college when general academic ability is held constant. Because of the way social class is typically defined, its influence is related to the influence of race and rural-urban community. These factors also have implications for level of career paths with minority backgrounds and rural backgrounds being associated with noncollegiate career paths.

TEACHERS AND PEER GROUPS

Both teachers and peer groups have been shown to have some influence on level of career path with the literature containing conflicting reports on the order of their influence. The literature reports that high school students on a collegiate level path tend to have friends on the same path and teachers' encouragement is related to pursuing the collegiate goal. It is not clear whether teachers or peers, independent of other factors, can effectively influence someone to pursue a collegiate level path.

How important other factors of geographic influences, religious background, aptitudes, interests and personality are in influencing levels of paths is extremely difficult to conclude from the literature. Religion and geographic influences tend to be studied as univariate factors so comparisons are not possible, and the response variables tend to be more related to direction of path than level of path.

Direction of career path. The literature that was reviewed leads to the tentative conclusion that there are some factors which are related to choosing a path leading to different careers within the two levels we have described.

SEX

The single most powerful influence on both level of career path and direction of career path is sex and the associated sex role. As we have indicated, a little over 50% of the boys graduating from high school enter baccalaureate programs within five years after high school, while only about 40% of the girls follow suit. The literature suggests that the college graduation rates are about the same, though. In terms of direction of career paths, engineering and agriculture are almost solely male paths while nursing and home economics are almost exclusively female. The social sciences have about equal proportions of both sexes while mathematics, physical science and biological science have four to six times as many men as women. Consequently, in those studies concentrating on the development of physical and biological science aspirants, it is popular to restrict the sample to boys. Differences in interest in science as a school subject are observed during the early school years and apparently continue throughout the educational years.

INTERESTS

The interest patterns of boys and girls have been shown to be slightly better predictors of direction of career development than have other factors. In discriminant analyses, interest and aptitude measures tend to dominate the directional function. Thus, students entering the physical sciences have high interest in science and low interest in business detail and outdoor activities. Students entering the social sciences tend to have high interest in welfare and social service activities. One of the findings which was discussed was the observation that college-bound students in general appear to have a high interest in the physical sciences. Consequently, discriminating between students who are likely to embark upon a career in sciences is difficult if only a single interest score is used. Manifest interests such as participation in science fairs in high school or extra class participation in science laboratory work do not seem to identify a future physical or biological scientist. When as many as 20 discrete career paths are identified, correlation coefficients between path membership and interest factors range from .19 to.35. Questions about how interest patterns are formed and what factors operate at what period of time to change interest patterns have yet to be satisfactorily answered. Although it can be concluded that students on different paths have different interest patterns, not much can be said about factors that influence those patterns.

APTITUDES

Even though interest patterns are somewhat more related to choosing a particular path, aptitudes seem to be only slightly less related to choosing a particular path and somewhat more related to changing directions during the educational years. Students entering engineering, mathematics, physics, chemistry, biology, and other physical and biological sciences tend to be more homogeneous with respect to abilities and interests than are students on a social science path. Physical science, mathematics, chemistry, and engineering students who persist on their path from high school through the baccalaureate years have greater mathematical and spatial relations aptitudes than students in other fields. High mechanical aptitudes apparently are characteristic of students going into technical careers. When as many as 20 or more discrete career paths are identified, correlations between path membership and aptitude measures typically range from .15 to .25. When 12 or fewer paths are identified, the correlations might range from .3 to .5. As is the case for interest factors, there are differences in patterns of aptitudes of members on different paths, but the differences are not strong enough by themselves to account for choosing, persisting, or changing directions.

FATHER'S OCCUPATION

The father's occupation has two implications in career development. The first has been discussed in the relationship of SES and career development. The second is much more specific. There is a pattern in the literature that suggests students in the physical and natural sciences tend to have fathers who have scientific or technical careers. Moreover, during the educational years male offspring tend to overchoose careers which are similar to their father's. The strength of this influence during the collegiate years is not known.

THE SCHOOL

It is our inclination to rank the school as the primary influence on career development because so many functions are served by schools and colleges. However, in the literature, school and college effects have not been substantiated, perhaps because of methodological difficulties. Nevertheless, it seems clear that teachers, counselors, and subject-matter experiences are related to directional development. It has been established that high school size is positively related to the proportion of physical and natural scientists from the school. Implicit in the finding is the assumption that the quality and quantity of physical and human resources in the sciences are related to school size. Whether teaching methods, amount of training of teachers, personal characteristics of teachers, and so forth are related to direction of career path has yet to be determined. When college and high school students are asked why they chose a particular path, one of the most frequent answers is intrinsic interest in the content of the field. School subjects allow the student to gain some superficial experiences with particular fields which deepens as the student progresses through school. In the physical sciences, engineering and biological sciences the structure of the training program also has effect. It tends to restrict movement onto those paths from other paths because of the cost in time and money to enter fields that are highly sequential in their training programs. Just how much effect the school curriculum has cannot be translated into correlation coefficients. It is possible that for college-bound students, it tends to be what might be called a one-way effect. That is, the curriculum programs may not attract students to different paths, but they do deflect them from their original goals and deter new entrants along the way.

The attempt at ordering the factors in terms of their weight in influencing career development toward the sciences leaves us with several impressions. First, with a few exceptions, the macro social systems of social class, racial and ethnic background, community, region of origin and religion are apparently more related to level than to direction of career path. The micro social systems of family, peers, and school seem to be more related to direction of career development. The general response variables like general academic ability, general interest in school and science tend to be more related to level of career development while aptitudes and specific interest patterns are more related to direction of development.

The second impression comes from looking at predictive validities. When as few as two levels and six directions are identified, about 40% of the students can be placed correctly on career paths through the use of sophisticated multivariate techniques. Multiple correlation coefficients between path membership and response variables range between .3 and .5. Comparable validity measures are observed by simply asking students what path they will be on in the future. So even the most sophisticated measurement techniques do not add much to what subjects themselves can predict, assuming they make a prediction. Moreover, even though the prediction of future development can be done with greater than chance accuracy with appropriate technology, more inaccurate predictions are made than are accurate ones.

The literature also suggests that in so far as measurement technology is accurate, there is no single overriding factor that differentiates chemists from physicists from mathematicians. The array and combinations of stimuli and response factors which operate are innumerable. One study found that when college freshmen are asked why they chose a particular major, the most popular response is "other." Precisely how a chemist ends up a chemist can and does vary widely. And even though it is easier to differentiate future physical scientists from future social scientists, or physicists or mathematicians, the major differentiation is done by those factors which are seemingly less subject to manipulation by environmental stimuli during the high school and collegiate years. However, aside from a handful of investigators, the influence of stimuli on direction of career paths has been largely neglected as an object of research.

Recommendations for Future Research

The survey of work in progress and the review of research should lead to recommendations about immediate and long range research needs. The survey of work in progress is described in Appendix B and the results are discussed there. Essentially they indicate that in career development work, little is being done currently with specific emphasis on the sciences as defined in this report. There are continuing projects and programs in career development research, but the current emphasis is on the process rather than prediction of outcomes.

One of the purposes of the review of research was to identify a consensus of recommendations for future research. As might be guessed, no such consensus exists. Thus the following discussion represents what we believe the future thrust of research ought to be. The recommendations are discussed as: (a) Design and Technical Considerations, (b) Sample Considerations, and (c) Topic Considerations.

Design and technical considerations. During the course of the review three topics related to design issues recurred frequently. First, the central thrust of predictive research has been on either stimulus or response factors. More attention needs to be paid to the interaction effects not only of response variables with each other and of stimulus variables with each other, but the interaction between stimulus and response variables. It is common for psychologists to use social class as an all-encompassing factor to account for stimulus variables and for sociologists to use intelligence tests to account for response variables. In each case the factors under study need to be broadened and the operational definitions of each factor appear to need further substantiation.

In this connection it is recommended that while not suitable for all purposes, multivariate procedures of measurement and analysis are generally necessary to adequately describe subjects in measurement space. Unifactor studies of the relationship between one factor, say general academic ability, and decision making have provided only limited insights into the phenomena. Interests, abilities, and personality factors are all necessary to describe subjects adequately and more than social class background constitutes the environmental press.

The last recommendation dealing with design issues comes from the apparent beneficial effects of merging the *process* with the *prediction* approaches to the study of career development. For example, process research has emphasized the multifaceted nature of the criteria and the qualities of the outcomes. It seems plausible that merging these considerations with specific outcomes will yield better understanding of both the process and the outcomes of development. This recommendation is suggesting that more emphasis be given to theories of career choice and development in predictive studies since most theoretical developments concern the process of development.

Sample considerations. There are four subpopulations about which little is known in terms of career development toward the sciences or other fields. One is women and a second is those who enter technical and paraprofessional fields. Most of the research that has been conducted to date has concentrated on male college students. Fortunately, some important work has included the paraprofessional levels of career paths and some has been concerned with the development of women. However, in comparison less is known about these two subpopulations than others.

Another subpopulation about which we know very little is graduate students. If it can be said that we know little about technically-oriented students, then it can be said that we know almost nothing about the developmental processes and outcomes during the graduate school years. It is clear that career development does not cease but continues throughout the adult life span. Consequently, it would be worthwhile to encourage research devoted to understanding development during the graduate school years.

Additionally, one of the potentially profitable ventures in research in the future would be to focus attention on what have been called "path jumpers." Students who are judged to be on one path and who suddenly change to a completely dissimilar path, as from physics to forestry, constitute a fourth subpopulation. By observing the factors involved in such radical changes, perhaps the understanding of career development will be enhanced.

Topic considerations. In making specific recommendations, several issues had to be faced. The first was whether more of the same sort of predictive research is needed; second, can correlations between path membership and predictor variables be enhanced and if so how, and third, how can recommendations be presented without reference to specific theories of development.

The answer to the first question is a qualified yes. More predictive kinds of research are needed with an emphasis on the interaction effects of environmental stimuli with personal attributes on specific career path outcomes. The disjunctive nature of the research which was reviewed made it difficult to rank order the stimuli and response factors in terms of the power of their influence. More research needs to be conducted with the explicit purpose of revealing the strength of relationships.

The answer to the second question is that improving the predictability of career path membership will be extremely difficult. Correlations between .30 and .55 seem to be a limit of some kind. The literature suggests three hypotheses. First, errors of measurement prevent better prediction. Second, it is clear that there is no single overwhelming factor that has or can be identified that marks a future scientist or any other career aspirant. Third, career development theories have not offered guidance for attempts to determine the role of economics and chance or opportunity or fortuitous circumstances. For example, it might be hypothesized that those factors which have the greatest single influence on development have been identified, yet the influence is not of sufficient magnitude to account for path membership, whether the factors are considered in concert or as unitary factors. In a way the hypothesis is saying that there are so many stimuli available, that within certain broad limits, anything is possible.

The absence of a specific theoretical framework has resulted in two difficulties in this report. The first is the loss of some explanatory powers in interpreting the findings and the second is to make the topics suggested below a bit more general than would otherwise be the case. However, the following topics are recommended for future research.

1. The logical consequence of the conclusions and earlier recommendations is to recommend that the interaction effects of stimulus and response variables be studied to see if the same level and directional dimensions of career path space continue to be observed during the years from high school entry to college entry.

2. As a part of the study of interaction effects, a concerted attempt at isolating the effect of the school and its associated stimuli on development toward the sciences would be rewarding for at least one major reason. It is through the educational system that social class effects, parental effects, and so on can be modified to reduce barriers to social mobility and development since the school is the locale of contact with all young peo-

ple. Moreover, even though the literature is not definitive, it does suggest that school effects may make the major contributions to directions of career development.

3. Study of career paths themselves and their associated decision points which appear to be less rigidly defined with each passing year is much needed. The stages or periods of career development are not clearly understood in the context of specific paths. Furthermore, decision points in development appear to be environmentally influenced and situationally determined, yet when those studying future scientists go to the literature on career paths, little can be found. Exploration is needed into the effects of using multidimensional space to describe paths by qualifying them in terms of vocational maturity, cohesiveness, and past experiences. Once the criteria of path membership are better understood perhaps the development of young people can be predicted with more accuracy.

4. Some other environmental factors need additional study. They are:
    (a) the independent contributions of father's career field on offspring's development,
    (b) the nature of the influence of parental expectations may be related to level of career development, yet the nature of parental expectations is little understood as are the ways in which those expectations are communicated,
    (c) the role of prestige of the career as conveyed via communications media has not been fully determined,
    (d) the role of economic considerations has been largely overlooked,
    (e) the effects of peer relationships have been shown to have some influence on direction of development, yet, like parental expectations, their nature and mode of communication have received only scant attention.

5. The role of opportunity in encountering stimuli is a potent source of information. In most of the instruments we observed which asked subjects to report influences on their career plans, opportunity for exposure to stimuli was never ascertained. Consequently, some study of opportunity is needed.

6. The totality of the realm of the cognitive processes which are typically referred to as the intellect has often been explored in studying career development. The parts of that totality and their independent contributions to specific outcomes have only partially been explored. It would be fruitful if research were conducted on the relationship between cognitive processes and career development. Some understanding is achieved through creativity research, but more is needed.

7. Another area worthy of study would be that of achievement motivation

and risk-taking behavior patterns as they affect career development. The usefulness of an index of interest in scholasticism as an effective differentiating factor between college-bound and noncollege-bound students suggests that differences in the nature and magnitude of achievement motivation can be observed in students on different paths.

The seven topic recommended for future research along with design and sampling considerations offer a fertile source of direction. In essence, the recommendations are intended to (a) make explicit the need for merging theoretical developments with methodological developments, (b) suggest that personal attribute-environmental stimuli-interaction research offers an appealing and potent direction for research, and (c) indicate that even in view of the large number of studies conducted on scientists and their development, a great deal needs to be done in both theoretical and empirical research.

The study of the career development of scientists during the educational as well as the working years is of considerable importance in our society because of their contributions to economic and social growth. The fact that there are no definitive answers to questions such as when is the crucial time period when students are attracted to or deflected from physics or social science is a reflection not only on the state of knowledge and methodology in psychology, but the nature of the fields, the differences among individuals, and the magnitude of the rate of change in career paths over time. Hopefully by concentrating future research on the understanding of the criteria and the interaction between the individual and his environment, our knowledge about the career development of scientists and nonscientists will be enhanced.

Appendix A

SYNTHESIS MODEL

Crites (1969) organized his discussion of correlates of vocational choice in the following way:

I. Stimulus Variables

A. Culture

B. Subculture—Social Class, Racial Background, Geographic Region

C. Community

D. Immediate Environment—The Family, The School, The Church

II. Organismic Variables

A. The Endocrine Glands

B. Physique

C. Heredity

III. Response Variables

A. Aptitudes—Vocational Choice, Vocational Preference, Vocational Aspiration

B. Interests

C. Factors Associated with Relationships between Choice and Interests

D. Personality—The Self-Concept, Ego Processes, Other Aspects of Personality

E. Theoretical Variables

1. Hypothetical Constructs

2. Intervening Variables

SURVEY OF WORK IN PROGRESS

The purpose of the survey of work in progress was to identify the on-going efforts, thrust, and nature of research being conducted on the career development of scientists and technicians. The survey was designed in two steps, the first of which was intended to identify those research projects being conducted and the second to identify the nature and purpose of the project.

Procedures

Following the literature search, the names and addresses of those making the most substantial and continuing contributions to the topic were secured. The rule of identification was simply that the scholar had to have published more than one article on the career development of scientists, and the latest article had to have been published since 1965. As a result of the application of the rules to the some 400 references that had been found, 57 such scholars were identified.

In addition, several sources of information about grants and contracts were reviewed to identify related studies. The sources are listed at the end of this Appendix.

Each person identified was contacted by mail with one follow-up. Replies were received from many of those contacted, either by phone or by mail. In four cases, interviews were arranged at national conferences.

Results

The results of the survey can lead to only one conclusion—there apparently are few studies specifically directed toward considering the career development of scientists and technicians during the educational years. A number of reports of results were received in time to be included in the bibliography and they were if the article was judged to be related to the topic of this report.

It is unfortunate that many of the original contributors are no longer working in this area (Barron, Chambers, Cooley, MacCurdy, Taylor and Terman, for example). Possible future references may include *Careers and Science: Empirical and Theoretical Studies* by Eiduson to be published by the Russell Sage Foundation; and a possible longitudinal study of the 1967-68 Harvard Project Physics study conducted by F. G. Watson.

It is encouraging that an increasing number of studies in progress are concentrating on minority groups, but these are, as yet, not specific to scientific and technical careers.

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